July-August 1983

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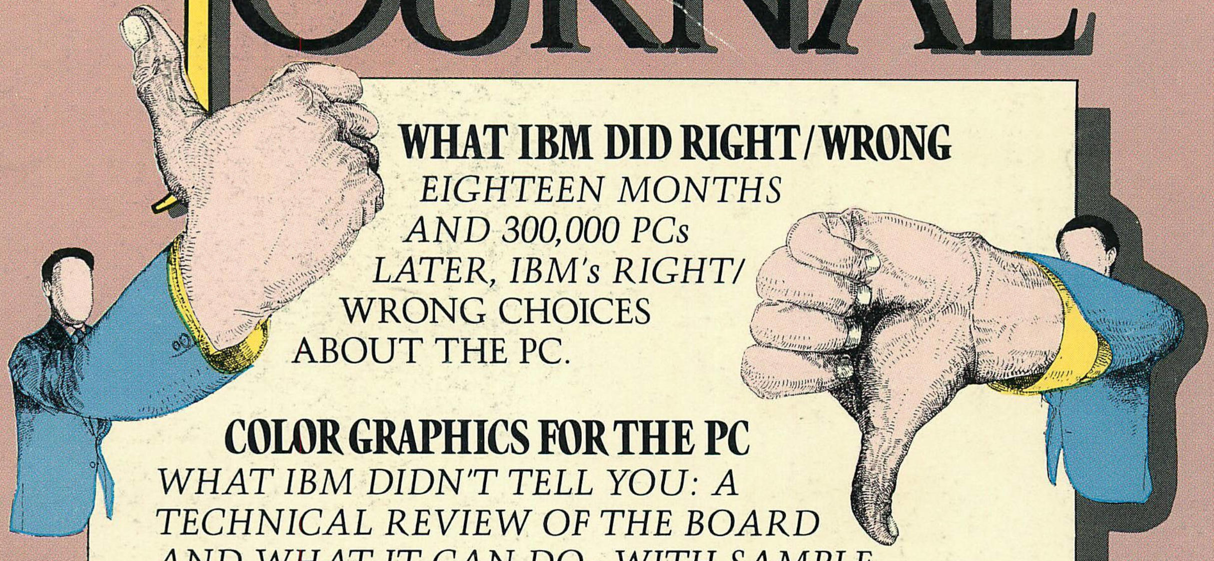
FOR IBM PERSONAL COMPUTER USERS

PC TECH JOURNAL



WHAT IBM DID RIGHT/WRONG

EIGHTEEN MONTHS AND 300,000 PCs LATER, IBM's RIGHT/WRONG CHOICES ABOUT THE PC.

COLOR GRAPHICS FOR THE PC

WHAT IBM DIDN'T TELL YOU: A TECHNICAL REVIEW OF THE BOARD AND WHAT IT CAN DO—WITH SAMPLE PROGRAMS.

CUSTOMIZING THE IBM DISPLAY

SEEING ON THE SCREEN THE SAME CHARACTERS A LETTER QUALITY PRINT WHEEL CAN PRINT.

THE XB BASIC PRECOMPILER

A DETAILED EXAMINATION OF A PRECOMPILER FOR IBM's BASIC INTERPRETER, WITH SOURCE LISTING.

HOW TO CHOOSE A C COMPILER

GUIDELINES FOR MAKING A SOUND DECISION.

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Expandable in 64K increments, Quadboard™ is socketed for 256K bytes of memory. Full parity and checking standard.

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With Qspool, you can also use part of system memory as a software print buffer. Choose from 8K to 56K of memory and stop waiting for your printer.

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This software program lets you use part of your total system memory as multiple disk drives. Super-fast drives that let you store important information for easy access.

Chronograph
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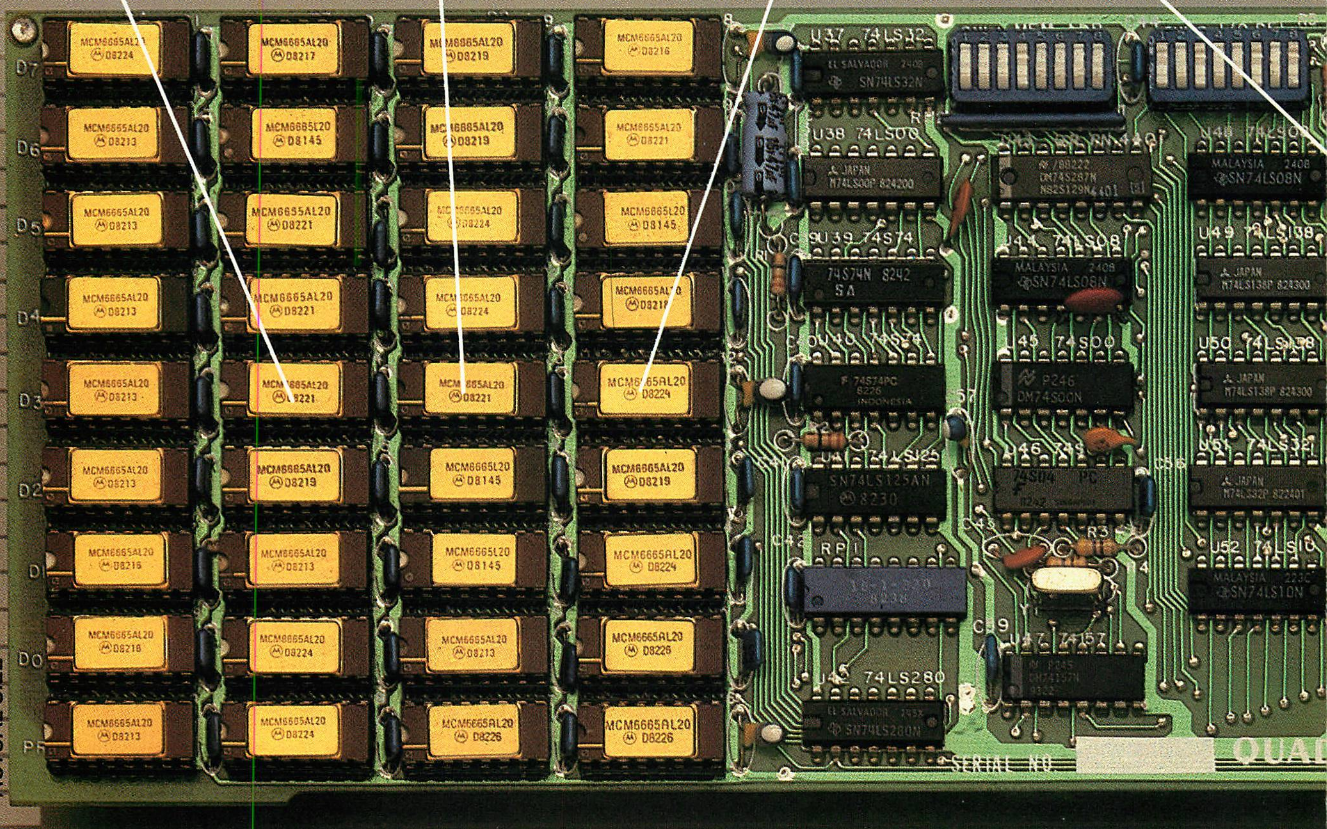

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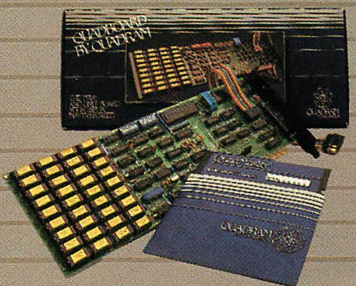

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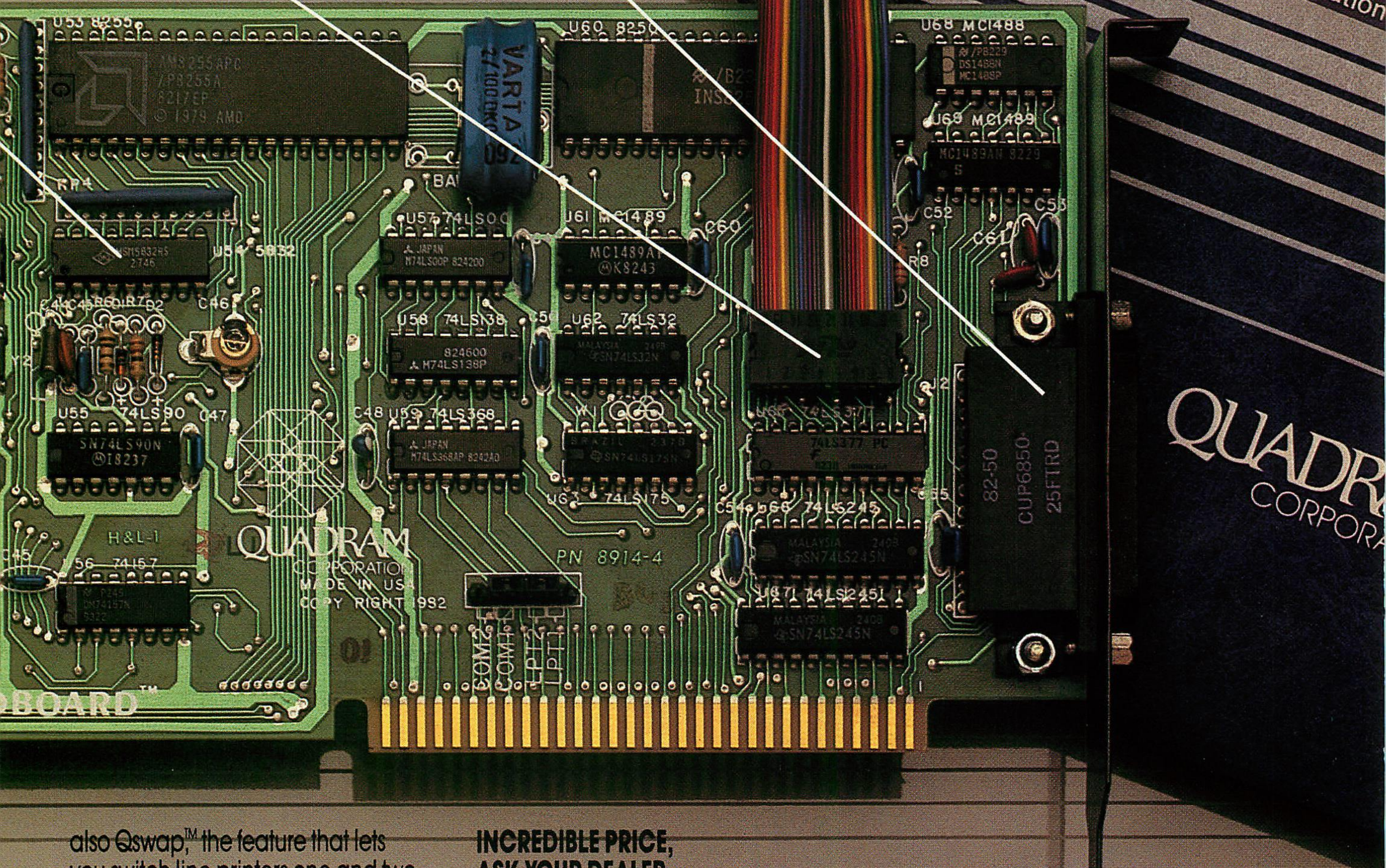

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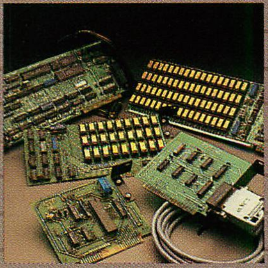

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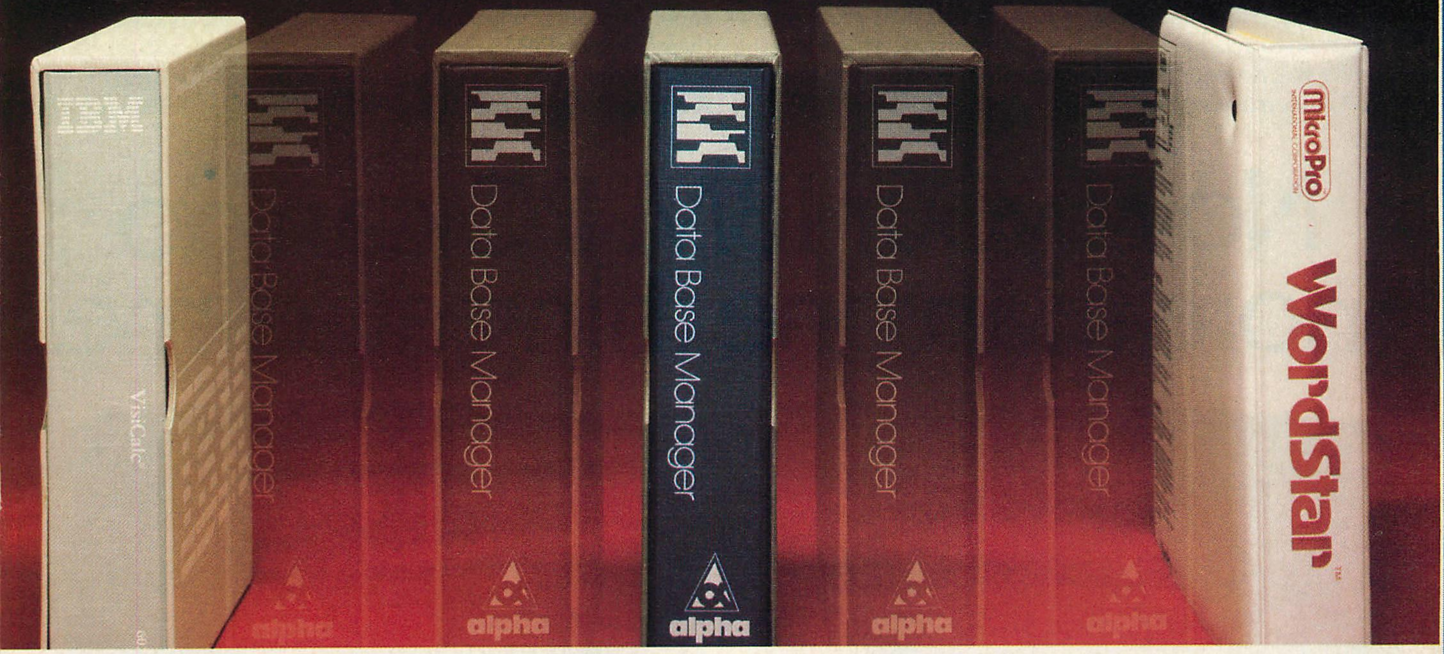
Split screen demo is for ad purposes only.

the VisiCalc® ⟷ Wordstar® Integrator



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From a **Data Base Manager II** Record (that you **sort** or **search** for):

```
      A                          B
1  FIRST NAME                ROGER
2  LAST NAME                 SMITH
3  BALANCE                    3261
4  PAST DUE                     30
5  CALCULATED INTEREST
6  AT 1.5%/MO
7  IS =                      48.92
```

Go to **VisiCalc** and Calculate Interest Charges

```
RECORD NUMBER 7
1  FIRST NAME   : ROGER
2  LAST NAME    : SMITH
3  BALANCE      : 3261
4  PAST DUE     : 30
```

```
L----!----!----!----!----!----!-
Dear Mr. Smith:
Your interest fee is $48.92.
Please remit this amount immediate
Your timeliness will be much apprec
```

Finally, go to **Wordstar** and Automatically **Mailmerge** a **Customized** message

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The creators of CP/M™

FOR IBM PERSONAL COMPUTER USERS

TECH JOURNAL

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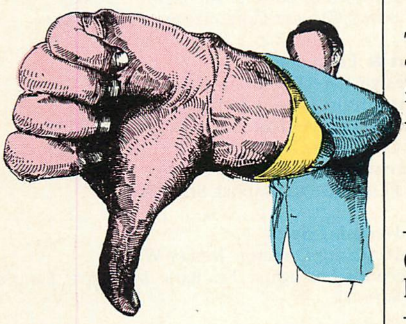
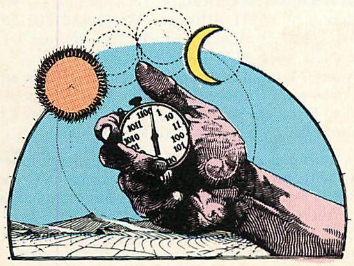


DEPARTMENTS



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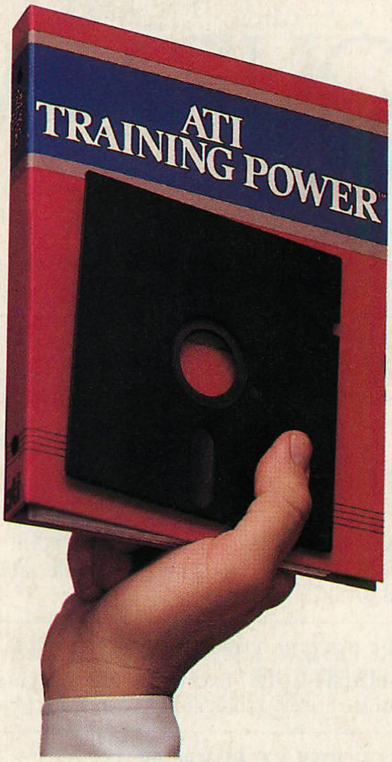

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- ☐ **MS-DOS**

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- ☐ **EasyPlanner**
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Programming
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- ☐ **dBASE II**
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FOR IBM PERSONAL COMPUTER USERS

TECH JOURNAL

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WILL FASTIE

DIRECTIONS

What Hath Z-D Wrought?

Six months ago. It was a peaceful time. I had my job, a very good job, in industry. There was R&D, there was some travel, there was a terrific group of people with whom to work, there was always something new around the corner.

"Hello?" It was Betsy, calling, I assumed, to ask me where my next "IBM Images" was.

"Hi!" It was in the mail; I had no fear.

"We're looking for an Editor for *PC*. Got any ideas?" sez she. I didn't. Recruiters always call and ask if you know anyone for a job when they really are feeling *you* out. But Betsy had never dissembled with me; I was not suspicious.

"How about you?" I was immediately suspicious.

"Pshaw, nonsense, crazy, ridiculous," I snorted. "What do I know about publishing? What do I care?"

"Okay, okay," she retorted. "I was just checking."

Like I said, a peaceful time, a little crazy when I stayed up late to work on "Images," but otherwise it . . . .

"Hello?" It was Betsy.

"Are you sure you don't want to be editor of *PC*?" I begin to realize that this is something I have to deal with.

"Who wants to know, anyway?" I challenge.

Uh, oh, *New York* wants to know. Well, I have such a good relationship with *Creative* that I don't want to risk it by offending *New York*.

(continued on page 10)


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Minimum System requirements: IBM Personal Computer with BOTH color & monochrome screens - 256K Memory - One disk drive

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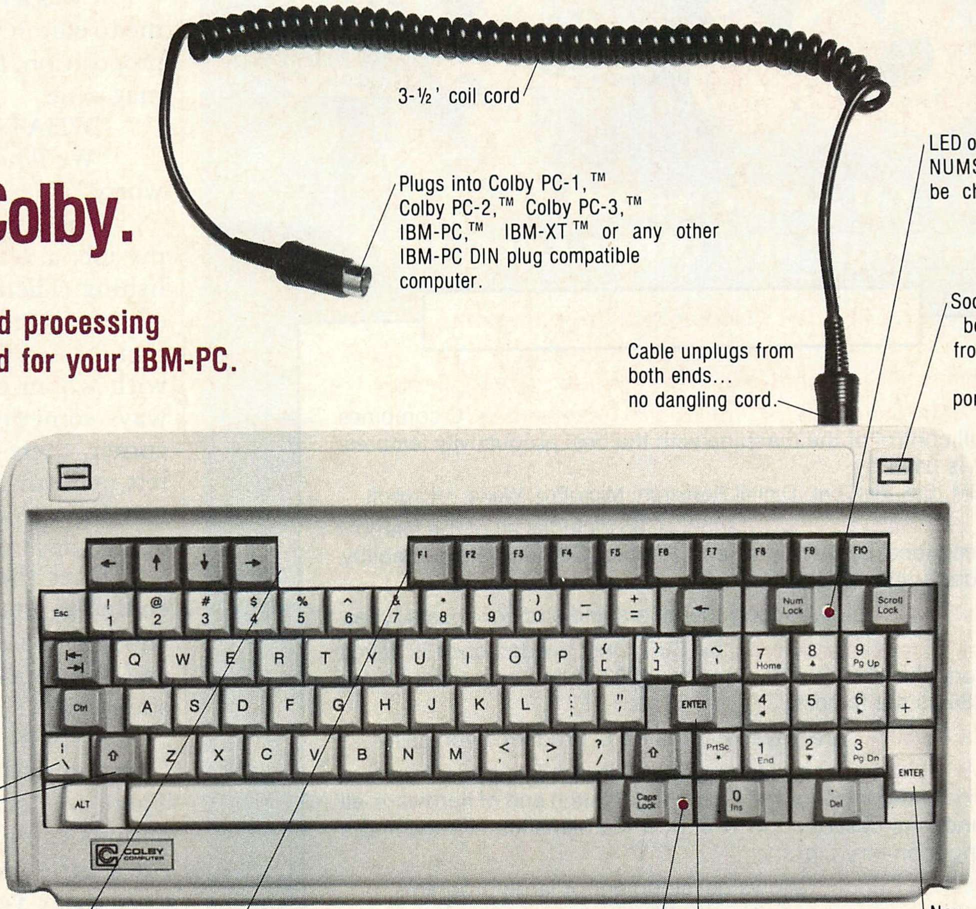

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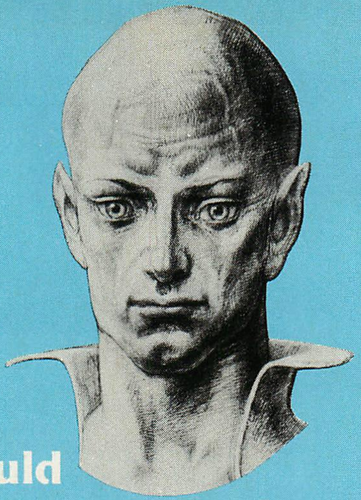

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DIRECTIONS

(continued from page 5)

"Okay." I am considerably humbled. "If they want to talk with me, I'll see them."

It was a lie. They didn't want me to edit *PC*, they had a terrifying proposition: I would start a new magazine.

"WHAT?"

"We'll help you, don't worry."

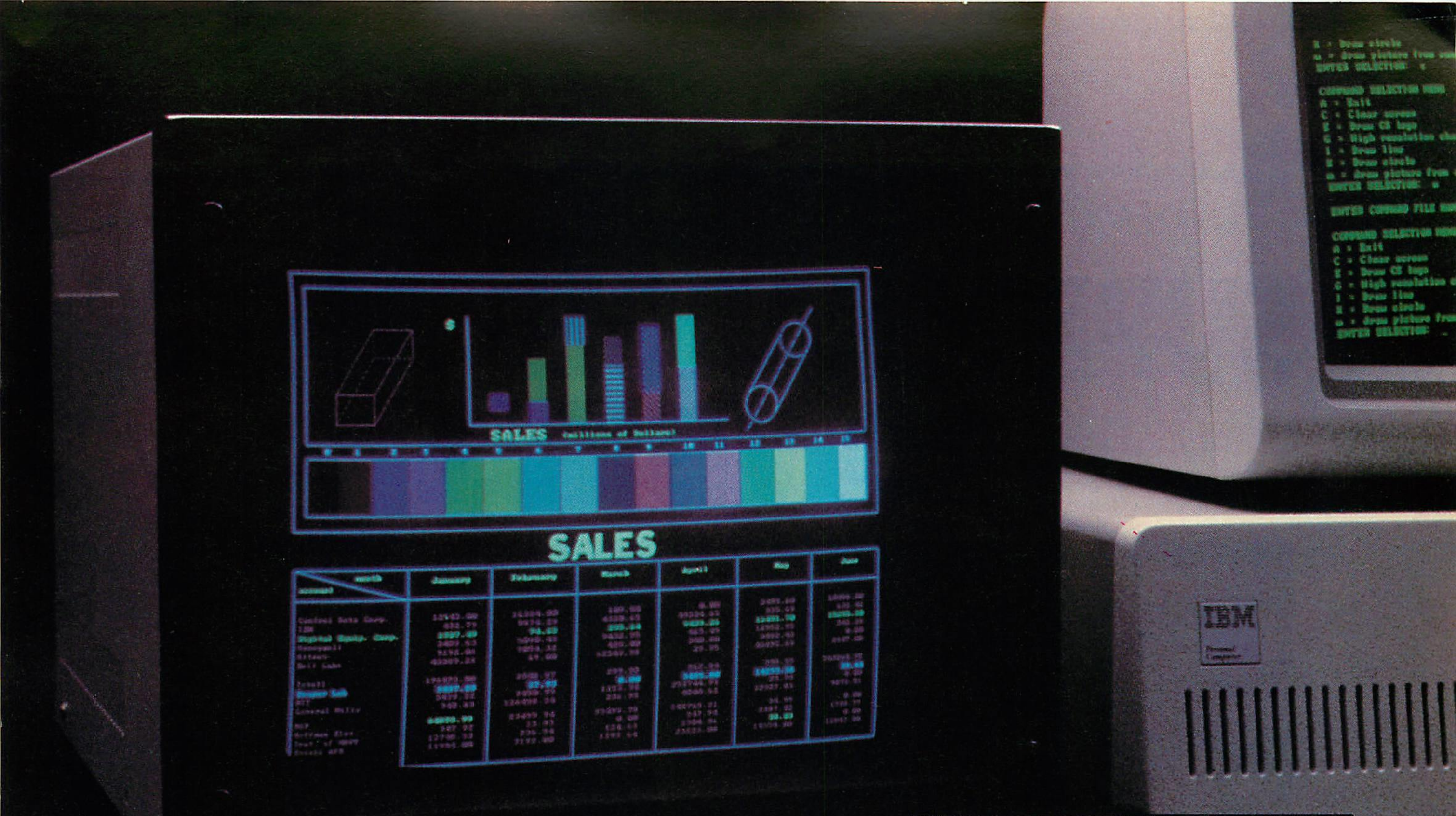
It is a hectic time. I have my job, a very good job, in publishing. There is writing, there is editing, there is some travel, there is a terrific group of people with whom to work, there is always something new around the corner, there is even some time left over for my family.

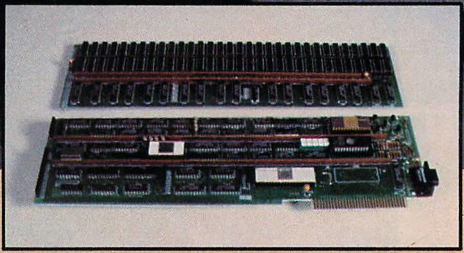
I never saw them coming, don't know what hit me.

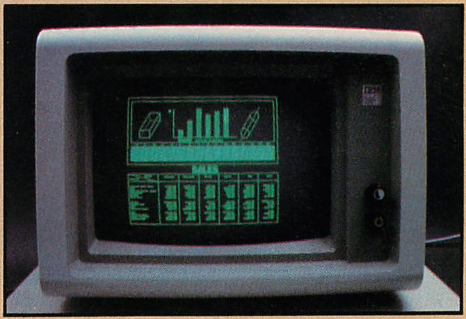
Does the world need another computer magazine? Does it need another one about IBM computers? We think the answer is a resounding "Yes!"

At first, the IBM Personal Computer seemed rather simple. There was one model and all the options came from IBM. Things got a little cloudy when some third party vendors got into the picture with add-in boards and peripherals, but even then things weren't too hard to figure out. Then the software started coming in droves, hardware from manufacturers of similar components became harder to distinguish, IBM announced the XT and the 3270 box, DOS 2.0 hit the stands, and XENIX and other UNIX systems began to get a lot of press. Oops, I almost forgot the portables and compatibles.

(continued on page 14)







ARTIST

Two High Performance Graphic Controllers for the IBM Personal Computer.

ARTIST transforms the IBM-PC into a graphics work station that would sell for over $30,000. Tektronix 40XX emulation software allows the IBM-PC to interface with mainframe graphics software.

Output frequencies are adjustable for any monitor. ARTIST can drive the IBM monochrome display with 16 levels of intensity and 11 patterns of shading.

ARTIST has its own graphics library accessible from any programming language under PC-DOS or QUNIX. ARTIST also supports CP/M-GSX which provides communication to printers, plotters, and digitizers.

FEATURES

- **16 colors**
- **16:1 display zoom**
- **16:1 character zoom**
- **Pan, scroll, paging**
- **Light pen**
- **DMA**
- **Mixed text and graphics**
- **Selectable character sets**
- **Solid & dotted lines**
- **11 shading patterns**
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- **NEC 7220 processor**
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1024 x 1024 Industrial graphics
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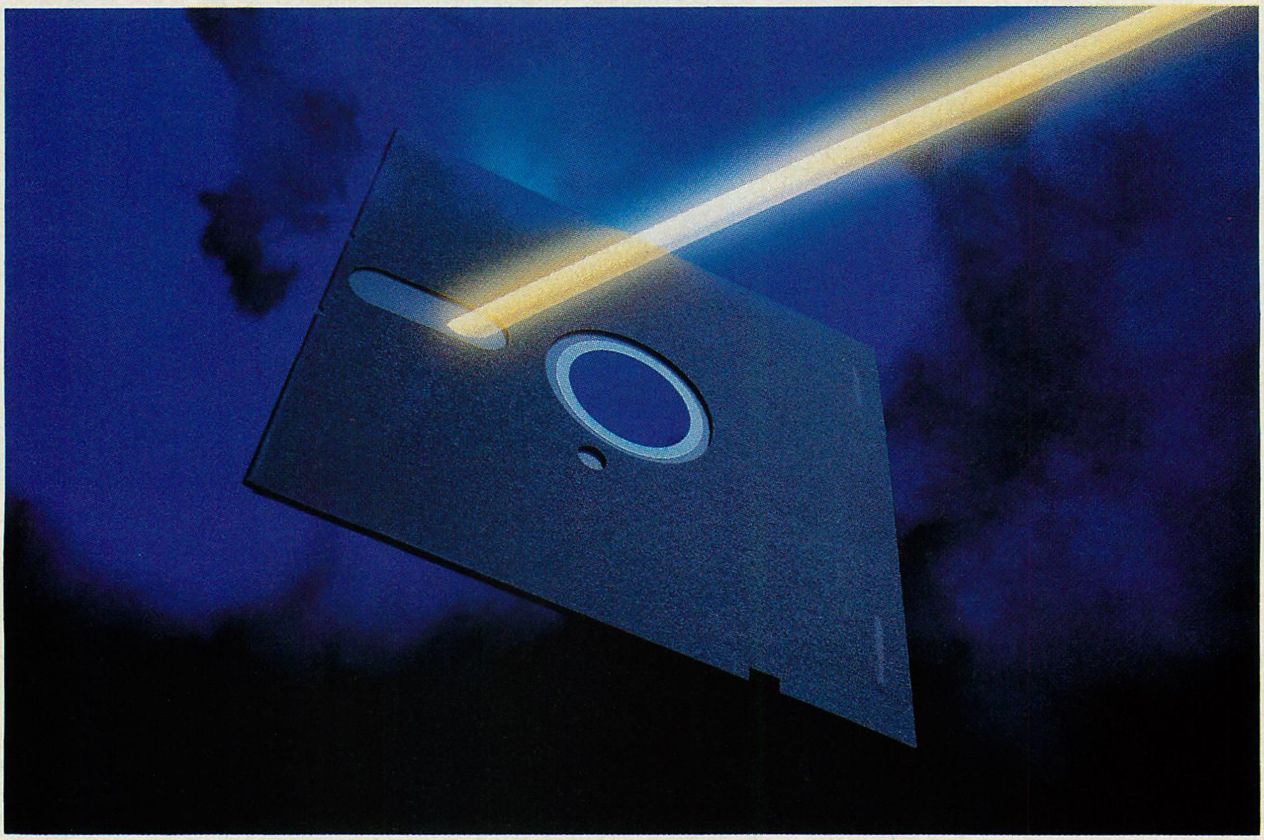
CIRCLE NO. 132 ON READER SERVICE CARD

TURBOFILE: SUPERCHARGED ACCESS TO VISIFILE™



You know and we know that VisiFile is probably the finest data base management system on the market today. We wrote and designed it to be.

But somebody asked us, "Can't you help us access our files and information in special ways . . . for our special needs?"

So we designed TurboFile. It offers you customized access, by letting you write BASIC programs that can read and write VisiFile files. For example, TurboFile allows you to access up to ten files simultaneously. Quickly and easily, by full key, partial key, or record number (that's *real* cross-referencing access). Using the BTree indexes already built and used by VisiFile.

Unlike other DBMS systems, TurboFile uses the same data files as VisiFile. What that means is that along with all of the powerful and friendly capabilities of VisiFile, you add TurboFile's unlimited programmability.

The best part is that TurboFile is so easy to use. As easy as saying GET, REPLACE, ADD, DELETE, or UNDELETE. TurboFile adds about 15 extra statements to BASIC for a host of special functions. At the same time, it removes the complications of BASIC programming.

This is one DBMS that is going to make you a lot more powerful. Because in the world of the microcomputer user, access is power. And TurboFile gives you access.

TurboFile is currently available for the IBM Personal Computer, and is priced at $195. For additional information call Creative Computer Applications, Inc. (603) 888-6648, or write PO Box 7074, Nashua, NH 03060. We're the ones who wrote VisiFile.

VISA and MASTERCARD accepted.

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TURBOFILE

NEW! TEN FUNCTIONS WITH SUPERSMART MODEM, 512K AND MOUSE READY...IN ONE SLOT!

Magnum 10 features:

1. **SuperSmart MODEM** The most sophisticated 300 or 1200 baud modem available, mounts inside the PC where it belongs!
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5. **EXTRA SERIAL PORT** For most letter quality printers.
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7. **GAME ADAPTER** Just plug in joy sticks, and enjoy the new PC games.
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9. **TurboRam** Software control of memory to give you hard disc performance from the extra RAM.
10. **TurboSpool** Assigns a portion of memory to feed the printer while you go on to other operations on the computer.

Magnum 10 with SuperSmart modem, and all software

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300 baud, 64K

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Touchtone decoder add	$ 50
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SuperSmart modem only with TurboCom and TurboFTA software

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300 baud

1200 baud add	$250
Touchtone decoder add	$ 50

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*introductory price

Compatible with WordStar, EasyWriter, Volkswriter and many other word processors. CP/M-80 version requires: 56K, 2 drives and 80 x 24 cursor addressable terminal. PC-DOS and MS-DOS versions require: 64K, 2 drives and 80 column display.

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DIRECTIONS

(continued from page 10)

The PC is no longer simple.

Actually, the PC was never simple. It was designed for a long life, which means it was designed to be extended and expanded as time went on. It was designed for a professional audience, people and companies who are demanding. It was designed to fill a broad set of needs, so that it could never be pigeonholed as a particular kind of computer. And it was designed to bring IBM convincingly into a market about which they knew virtually nothing.

That's a complex system.

It appears that IBM did a very good job providing information about the machine and software. The books are voluminous and usually well-done. The *Technical Reference* even has schematics and ROM listings. They are mostly complete and accurate. But the body of documented information is lacking in two ways. First, it is not all there. There are obvious omissions: parts of schematics are missing, things visible on a circuit board or schematic are not explained, and ways to do important things are not provided. Second, even when it *appears* to be there, it often is incomplete. The manuals tell you most things, but can't answer all questions.

In this issue we feature an article by Tom Hoffman that tells you more than you might want to know about the IBM Color Graphics Adapter, and certainly more than the *Technical Reference* does. We hope to carry articles like this regularly be-

(continued on page 180)

Call for Papers: ACM SIGSOFT/SIGPLAN Software Engineering Symposium on Practical Software Development Environments
April 24-25, 1984
Carnegie-Mellon University
Pittsburgh, PA
Submission deadline: October 20, 1983
Acceptance Notification: December 20, 1983
Camera-ready paper due: February 8, 1984
Topics of interest: internal program representations, syntax and semantic directed editing, code generation and interpretation schemes, support for testing and debugging, space/time efficiency trade-offs, display and screen formatting techniques, user interfaces on language design.
Send 10 copies of extended abstract to
Peter B. Henderson
Department of Computer Science
SUNY Stony Brook
Stony Brook, NY 11794

CGA 83. National Computer Graphics Association Annual Conference
June 26-30
Chicago, IL
703-698-9600

Softfair. Software Development Tools, Techniques, and Alternatives
July 25-28
Cosponsored by IEEE Computer Society,
National Bureau of Standards
Hyatt Regency Crystal City
Arlington, VA
301-589-8142

Institute in Computer Science
July-August
University of California, Santa Cruz
University Extension
Carriage House
Santa Cruz, CA 95064
408-429-4534

Siggraph 83, 10th Annual Conference on Computer Graphics and Interactive Techniques
July 25-29
Detroit, MI
312-644-6610

Harvard Computer Graphics Conference
July 31-August 4
Cambridge, MA
617-495-9345

Compcon Fall 83
September 26-29
Arlington, VA
301-589-8142

PC '83/East
October 8-10
Bayside Exposition Center
Boston, MA
800-841-7000

The National Software Show
October 19-21
Trade Show Center
San Francisco, CA
800-732-2300

ACM 1983 Annual Conference
October 24-26
Sheraton Centre
New York, NY
212-620-5055

Compsac 83
IEEE Computer Society's Seventh International Computer Software and Applications Conference
November 7-11
Chicago, IL
301-589-8142

ACM Conference on Personal and Small Computers
December 8-9
Westgate Hotel
San Diego, CA

PC Tech Journal *will publish notice of upcoming conferences and seminars and calls for papers. Please send the pertinent information as far in advance as possible to PC Tech Journal, The World Trade Center, Suite 211, Baltimore, MD 21202.*

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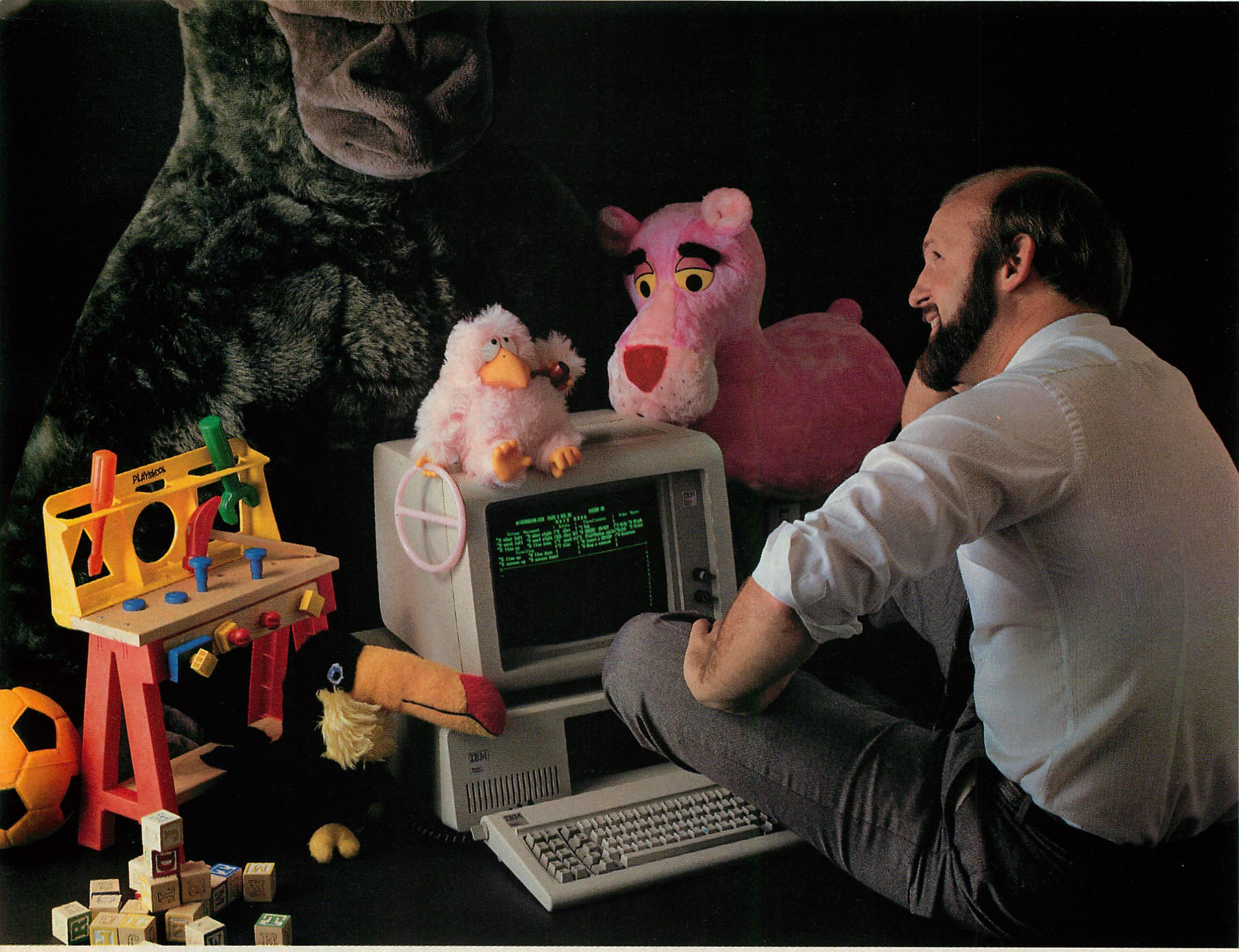


This Programming professional deserves a lot more from his personal computer.

He's earned it. As a seasoned professional, he's learned to master some of the world's most advanced programming tools. Tools specially designed to meet the everyday demands of programming experts.

But as the owner of a personal computer, he's come to expect less. Less performance. Less sophistication. And less flexibility.

Why should programming a personal computer be any different?

Prior to the announcement of micro/SPF™ development software, experienced programmers felt programming a personal computer was a lot like playing with a toy. You couldn't take it seriously.

But today, there's micro/SPF,™ a solution to elementary program editing tools now offered with most micro-computers.

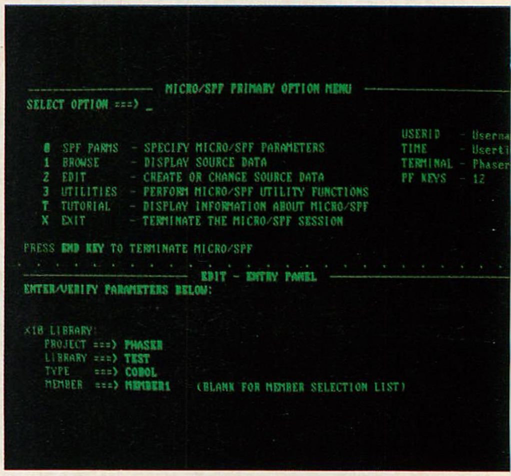
With micro/SPF™ you get the same procedures and commands experienced programmers are accustomed to using at work. By mimicking features found in standard SPF software, micro/SPF™ provides all the sophisticated utilities programming professionals expect.

Programming experts can take advantage of skills they've spent years perfecting.

Now, for the first time, mainframe software is available for personal computers. SPF screens are fully reproduced in logical sequence and each screen is formatted identical to those found in the SPF system.

In addition, micro/SPF™ comes equipped with the same primary and line commands, tutorial messages and program editor (with program function keys) experienced programmers are used to.

Programming professionals who've spent years perfecting the art of writing sophisticated code deserve to work with state-of-the-art tools, not toys. Find out how micro/SPF™ can help you do work-compatible programming on your personal computer today!



PHASER

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PROFESSIONAL

PROGRAMMING·TOOLS

ProEdit II

Speed up your program development! With ProEdit II you can perform complex text manipulations with the speed and power your IBM PC was meant for— at half the price of comparable editors. Compare these features: True full screen editing with horizontal and vertical scrolling ■ Word wrap ■ Automatic disk buffering ■ Easy recovery from disk full errors ■ Full DOS command support ■ High quality documentation ■ COMMANDS that allow you to: Rapidly move, copy, replace, and delete text ■ Display and edit multiple files ■ Customize your ALT keys for use with any programming language ■ Easily repeat a set of commands with one key ■ Customize your print output ■ Custom tailor your function keys ...

These are just some of the powerful features of ProEdit II. Compare us with the competition. You will see that ProEdit II contains the features you need at an affordable price—only **$129.00**, or order just the manual for $40.00.

DYNAMIC SCREENFORMS

Dynamic Screenforms is a versatile screen design/data handling package designed for the serious microcomputer programmer, and yet so simple to use that even an amateur can create BASIC code for applications software in a fraction of the normal time. You can now create and maintain programs written in BASIC with the power and flexibility that professional programmers demand. Your programs will allow the end-user maximum full-screen data input flexibility; fast file access, and error checking. You get all of the power of Dynamic Screenforms now for only **$99.00**, or order just the manual for only $40.00.

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ComNet™ FROM TECMAR

NETWORKING
- Ethernet
- Electronic mail
- Device sharing
- No dedicated server required
- Operates with no floppy-based system
- Remote job execution
- File lock out
- Password protection
- Server back-up available

TELEPHONE SUPPORT
(available through modem board)
- Autodial - with extended telephone numbers
- Auto Redial
- Call Forwarding
- Length Of Call Indicator
- Directory Support - with unlimited number storage
- Message Support - either leave or obtain messages. Receive messages remotely
- This unit (with a handset) substitutes for a telephone

MODEM
- Gateway to networks
- Electronic mail
- Device sharing
- Remote job execution
- File lock out
- Password protection
- 300 to 1200 baud modems available
- Data in network can be obtained by decoding touch-tone sequence or through voice recognition prompt
- Respond to remote terminal
- Access dictating systems on network. Control them by touch-tone decoding
- Programs or calculator can be used remotely. The touch-tone keypad can be used to provide numeric input to programs or the calculator from a remote site (programs are loaded by decoding touch-tone sequences).

VOICE
- Voice mail
- Voice annotated text
- Voice messages

VOICE RECOGNITION
- Transparent keyboard. Speak instead of type
- Give commands over phone

ComNet

ComNet is designed to meet your total communication needs including computer to computer (networking), person-to-computer and person-to-person communication requirements for data and voice.

The network protocol employed is the industry standard high speed Ethernet which permits a number of IBM PC's to be linked together by ordinary thin coaxial cable. In addition to its own computer's power, a user has the availability of other devices which are also attached to the cable - such as various printers, plotters, large disks, etc.

All versions of ComNet include an Ethernet interface and conversion of voice into data and back again. This enables one to give and recieve spoken messages from any location, as well as storing the message for later transcription. The SECRETARY is the basic system with these features.

SECRETARY $1695¹
- Ethernet Link
- Ethernet Companion
- ComNet Software

EXECUTIVE $2995¹
- Ethernet Link
- Ethernet Companion
- Modem (300 Baud)²
- Voice Recognition
- Microphone
- ComNet Software

¹With **1st MATE**, **2nd MATE**, or **3rd MATE** in Station

²Option: 1200 Baud Modem

IMPROVE PRODUCTIVITY THROUGH TOTAL COMMUNICATIONS SUPPORT

DICTATING SYSTEM

- Control the Pearlcorder X-02 or XR dictating system at local or remote stations through keyboard or foot pedal control or by telephone touch-tone decoding. Allows you to dictate to the "ComNet" system from any place in the world.

FOOT PEDAL SUPPORT

- Controls dictating system
- Controls response to voice recognition

SOFTWARE

- Time Management - alerts you to appointments at any station you are logged onto.
- Message Management - either electronic mail or voice.
- Clock/Calendar - either visual or audible
- Calculator - either visual or audible
- Voice Management - oversees voice mail, voice message and voice annotated text operations

These software packages can be operated through voice recognition (even over telephone) with voice output, through the telephone keypad with voice output or through the IBM PC keyboard

The MANAGER system adds a modem which can turn the PC into a telephone if a separate handset is added. The modem enables the MANAGER to receive unattended voice and data from any telephone in the world. The MANAGER can key in commands thru the decoding of the tones in the telephone keypad.

The EXECUTIVE is the most complete implementation of ComNet, adding computer recognition of spoken commands. An executive might phone the PC to leave or retrieve messages or request specific information. The PC, in a spoken voice, can request the user's access code (or respond to questions regarding which of several options is desired). The EXECUTIVE has the option of keying in answers or commands with the phone's tone dialing buttons, or simply speaking the answer or commands.

HARDWARE

ETHERNET LINK — $950
Permits communications between computers at extremely high speeds (10 Mbits per second). The transmission mode is through single video coaxial cable with easy-to-use BNC connectors.

ETHERNET COMPANION — $695
Performs the function of voice digitization and voice replay, dictation machine control and foot pedal control. Also contains interface for mouse.

MODEM
103 (300 Baud) — $295
212A (1200 Baud) — $695

- 103 (300 Baud) or 212A (300 or 1200 Baud)
- Pulse/tone automatic dialer
- Dual tone DTMF receiver (decodes touch tones)
- Auxiliary voice circuit
- Auxiliary, optically coupled, ring indicator output (capable of being used for auto power-on)
- Can replace telephone with the addition of a handset

VOICE RECOGNITION — $995
MICROPHONE — $170
User-dependent 100 word recognition (200 words optional) with 98% accuracy. Permits computer to respond to voice input.

MORE TO COME...
ComNet FROM TECMAR
AVAILABLE IN JULY, 1983

MANAGER $1995[1]

- Ethernet Link
- Ethernet Companion
- Modem (300 Baud)[2]
- ComNet Software

TECMAR
6225 Cochran Road
Solon, Ohio 44139

CIRCLE NO. 213 ON READER SERVICE CARD

TECH NEWS

Faster Printer

Epson America, Inc., manufacturers of the trusty MX line of dot-matrix printers, has introduced the FX-80, a high-performance, bidirectional printer that combines a printing speed of 160 characters per second with the availability of four printing densities, three spacing options, and three basic type styles. It features 9 x 9 dot-matrix characters with descenders, proportional spacing, and the ability to employ user-defined type fonts. This feature will be especially useful to math, engineering, foreign language, and medical applications.

The FX-80 also has a one-to-one graphics ratio—the dot-matrix has the same scale vertically as horizontally—so that accurate graphics, including true circles, can be drawn with the FX-80's dot-addressable graphics capability.

Business users will appreciate the short-form tear-off bar, which will aid the production of computer-generated paychecks and other pre-printed forms. The tear-off bar separates the paper from the printer one inch from the last printed line.

Suggested retail price: $699.

EPSON AMERICA INC.
3415 Kashiwa Street
Torrance, CA 90505
213-539-9140

CIRCLE NO. 282 ON READER SERVICE CARD

Parity Trap Utility

Daystar Systems, Inc. of Dallas has introduced a parity error handling utility program for the PC called UltraTRAP®. It is available on UltraFast®, a three-program utility package from Daystar.

UltraTRAP will intercept and circumvent the normal parity handler. For most soft error occurrences it will reset the parity error detection circuitry and report the condition to the user via the monitor. The user may then choose to ignore the error, abort the current program and return to the operating system, or re-boot the system via a "warm boot" sequence.

With UltraTRAP on the UltraFAST software diskette is UltraBOOT®, a dynamic memory allocation utility, and UltraFAST, a flexible disk RAM emulator.

Suggested retail price: $39.95 or free with the purchase of one 512KB UltraRAM add-on IBM-PC memory board, $895.

DAYSTAR SYSTEMS, INC.
10511 Church Road, Suite L
Dallas, TX 75238
214-341-8136

CIRCLE NO. 284 ON READER SERVICE CARD

Packing the PC

Fiberbilt now offers two sets of carrying cases for the PC: a heavy-duty shipping case and a light-weight flight case. One case in each set holds the CPU and the keyboard, with room under the CPU for software packages. The other holds the IBM monitor and IBM or MX-80 printer.

The heavy-duty cases, of steel angle construction, meet the Airline Transportation Association spec 300 criteria. The lighter sets are of aluminum frame construction, each piece weighing just less than 20 pounds. They are fully foam padded and have key locks.

The light-weight set costs $161 for the CPU-keyboard case and $171 for the display-printer case. The heavy-duty set is $264 for the CPU-keyboard case and $268 for the display-printer case. Prices are FOB New York. Phone orders can be charged to VISA, Mastercard, or American Express.

FIBERBILT
Ikelheimer-Ernst, Inc.
601 West 26th Street
New York, NY 10001
800-847-4176

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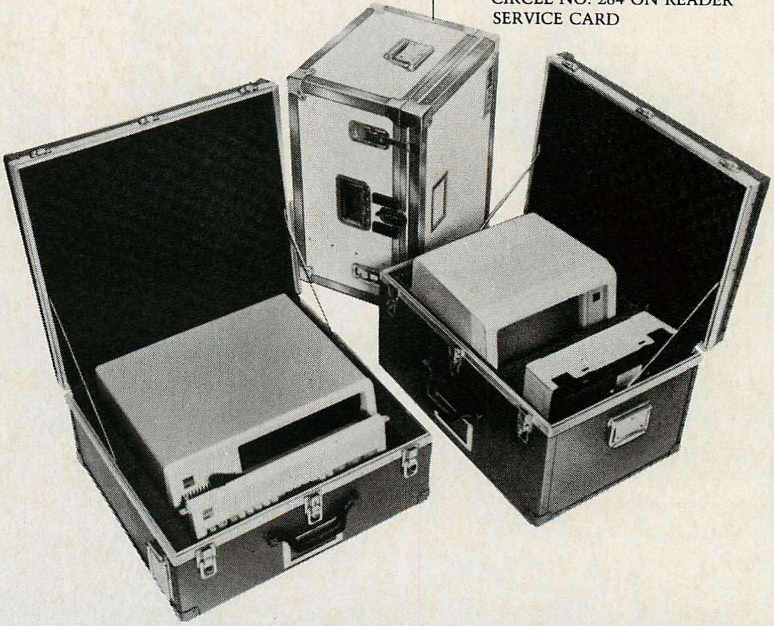

MBP Cobol Compiler GSA Certified

The ANSI '74 mbp COBOL Compiler has been certified to meet all Level II specifications for Nucleus, Table Handling, Sequential I/O, Relative I/O, Indexed I/O, and Segmentation Modules. Library, Debug, and Interprogram Communications modules were all certified as Level I with several extensions.

The first true COBOL Compiler for Intel 8088/86-based microcomputers, mdp COBOL generates native machine language object code that executes at least four times faster than conventional interpreter alternatives. mbp, Mathematischer Beratungs- und Programmierungsdienst, is headquartered in Dortmund, West Germany.

Suggested retail price: $500
mbp
7700 Edgewater Drive
Suite 360
Oakland, CA 94621
415-632-1555
CIRCLE NO. 285 ON READER SERVICE CARD

On-Site Service

IBM has added on-site service to it's list of maintenance options for the PC and the PC-XT. Initially the option is available in 38 of the cities having an IBM service/exchange center. The new service will cost about 25 percent more than the courier pick-up option. IBM's three other maintenance options—courier pick-up, carry-in, and mail-in—have been reduced in cost by approximately 10 to 18 percent.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Customer Service Division
400 Parson's Pond Drive
Franklin Lakes, NJ 07417
800-428-2569
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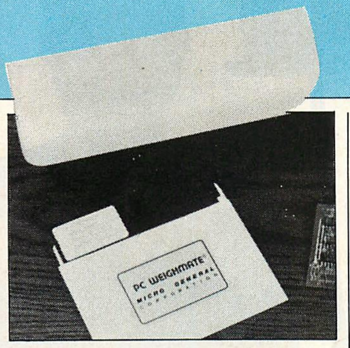

PC as a Postage Scale

Micro General Corporation has a new PC WEIGHMATE scale system that converts the PC (or Apple II) to an electronic postal, shipping, and counting scale. The WEIGHMATE consists of a 25-pound capacity scale platform, which interfaces via an available rear slot, and a floppy diskette, which contains the menu-driven software, rate tables, and zone charts for all classes of USPS domestic and international mail, Express, United Parcel Service, and Federal Express.

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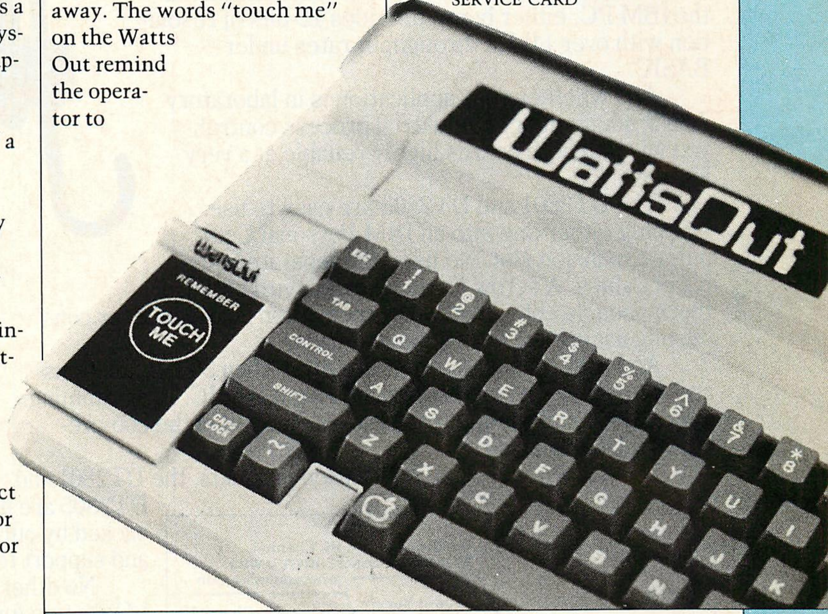

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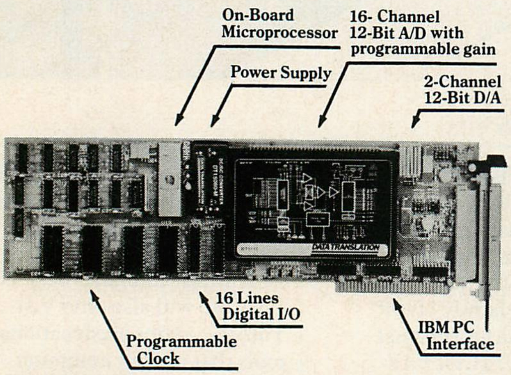

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TECH NEWS

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(continued on page 132)

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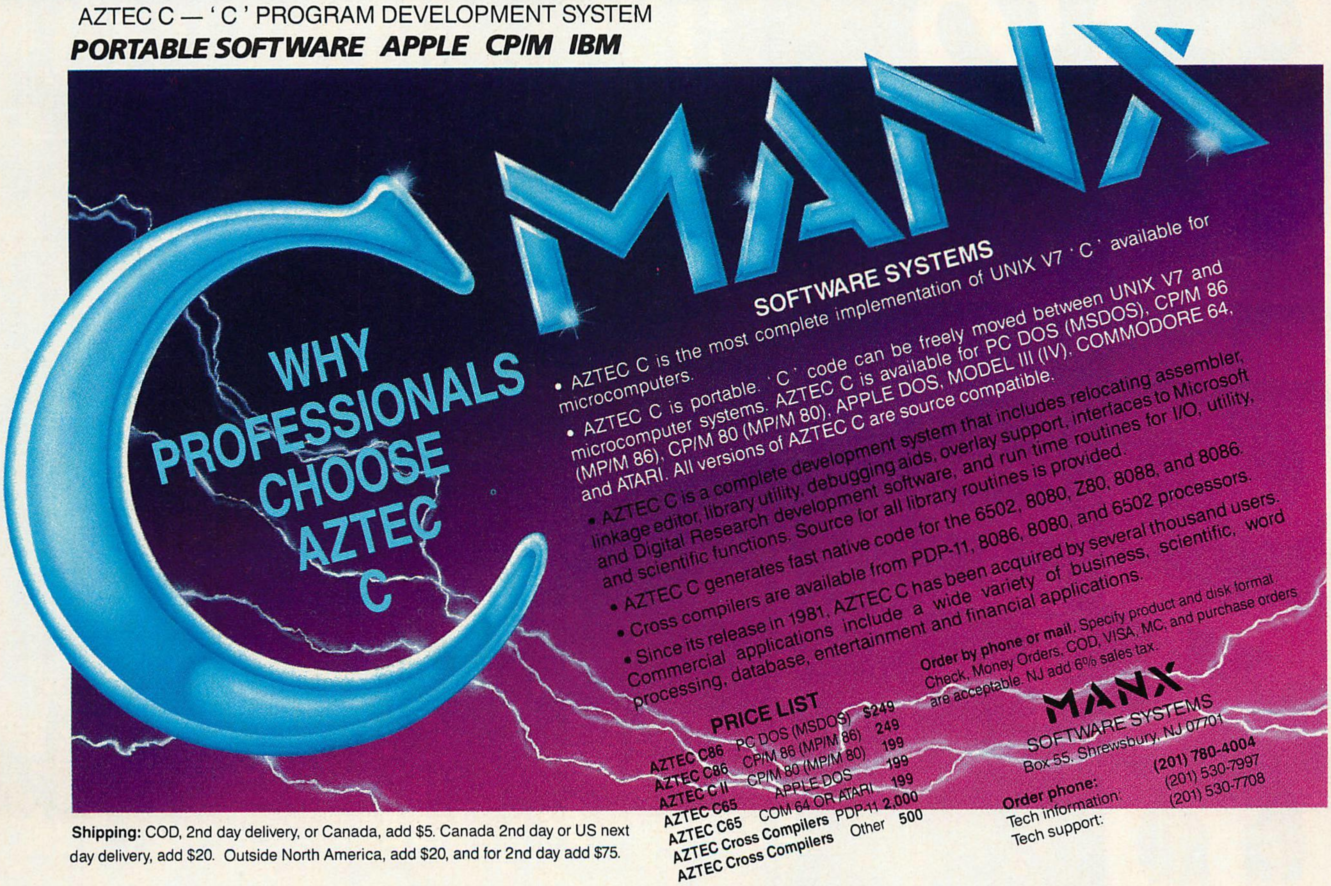

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The IBM Color/Graphics Adapter

A PROGRAMMER'S GUIDE TO THE COLOR DISPLAY ADAPTER: FILLING IN THE INFORMATION GAP LEFT BY THE AVAILABLE IBM LITERATURE

THOMAS V. HOFFMANN

"I can't come back, I don't know how it works!"—The Wizard of Oz

There's no doubt the Wizard of Oz was clever. To reward them for their watery withering of the Wicked Witch of the West, he concocted courage for the Lion, bestowed brains on the Scarecrow, and gave a hearty handout to the Tin Woodsman. But when he tried to deliver Dorothy to Kansas in his used balloon, he was helplessly carried away, and the old gasbag

was never seen again. His final exclamation, reproduced above, illustrates that cleverness is more ingenuity than knowledge, and of considerably less use in dealing with high technology.

So while it's interesting to read on page 2-46 of the Technical Reference Manual that the IBM Color/Graphics Monitor Adapter is "highly programmable," and that "many additional modes are possible with clever programming," it's not very helpful. And knowing that 16 color 160 by 100 low resolution graphics is "not supported in ROM" and "requires special programming" is tantalizing, but hardly informative. Is clever programming more difficult than special programming? If we knew how the adapter works, perhaps ordinary programming would suffice.

This article is a programmer's guide to the color display adapter, filling in much of the information gap left by the available IBM litera-

ture. The additional information comes from various sources: logic diagrams and program listings in the Technical Reference Manual, component data sheets, experiments, and the display card itself.

We will begin with a brief overview of the color adapter hardware organization, then review the standard alpha and graphics modes available from BASIC. Next there is a detailed description of the programmable features of the adapter, including the Motorola 6845 CRT controller. Along the way we present two different techniques for 16 color graphics programming, which IBM only hints about: the one used in the Microsoft Flight Simulator that only works with composite monitors or TV sets, and another low resolution technique that works on any color display.

Hardware Overview

The Color Graphics Monitor Adapter is a single printed circuit card, which fits into one of the expansion bus slots in the PC motherboard. IBM recommends that it always be placed in slot number two. Since the color card is deeper than other cards, there is the possibility that pressure on the top of the case could damage the card or components under it if it were in slot three. The Monochrome Display Adapter should go in slot three if your system has both adapters.

WHILE IT'S INTERESTING THAT THE IBM COLOR/GRAPHICS MONITOR ADAPTER IS "HIGHLY PROGRAMMABLE," AND THAT "MANY ADDITIONAL MODES ARE POSSIBLE WITH CLEVER PROGRAMMING," IT'S NOT VERY HELPFUL.

The major elements of the color adapter are the Motorola 6845 CRT controller chip, a 16K byte display buffer memory, a ROM character generator, and mode, color, light pen control, and status registers. Figure 1 is a block diagram which shows the major data paths connecting these elements.

The 6845 CRT controller is the heart of the adapter. It provides the basic horizontal and vertical video timing signals and generates the addresses for accessing the display buffer and character generator.

The display buffer RAM resides in the 8088 CPU address space at segment &HB8OO, and can be accessed by both the CPU and the adapter's video generation logic. [Note: Hexadecimal numbers in the text are preceded by &H, the standard BASIC notation.] Data stored in the buffer by the CPU are read out two bytes at a time into two 8-bit data latches. From there, the data passes to the serializer logic (going through the character generator in alpha mode), which extracts one picture element, or pixel, at a time, and then to the color encoder where it is turned into RGB or composite video information for output to the display.

The character generator is an 8K byte read-only memory, which contains the patterns used to generate dot matrix characters in alpha modes. This ROM actually con-

tains three sets of patterns, each defining 256 characters, and is the same chip used in the Monochrome Display Adapter. On the color card only 2K bytes are used, eight bytes per character, with each of the eight bits in a byte representing a dot in the 8x8 character cell. This ROM cannot be read by the CPU, so there is a copy of the first 128 character patterns in BIOS ROM, which is used in graphics modes to generate characters under software control.

There is a minor mystery surrounding the character generator. The Technical Reference Manual mentions a jumper that can select either a 5x7 single dot font or 7x7 character double dot font. The terms single and double dot usually refer to the width of each displayed pixel; characters look better on low resolution displays if the dots are wider. My adapter has no jumper, and the logic diagrams don't show one either, but the card generates 7x7 characters, which is consistent with no jumper being installed. It's not clear what IBM means by single and double dot fonts.

The mode and color control registers determine the operating mode and overall color attributes, and are described in detail in the programming section below.

Theory of Operation

The adapter has two major operating modes, alphanumeric and graphics. In both modes, information stored in the display buffer is continuously read out, interpreted, and displayed. The display image is composed of 200 lines of 320 or 640 dots called picture elements or pixels. The difference between alpha and graphics mode is in the interpretation of the stored data.

Photo 1: IRGB Color Chart

Photo 2: Artifact Color Chart

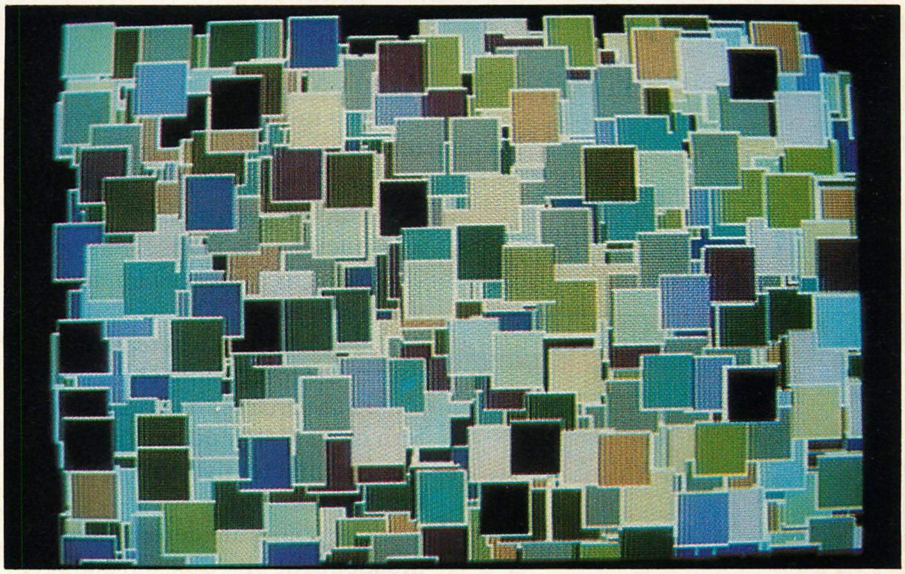


Photo 3: BOXES

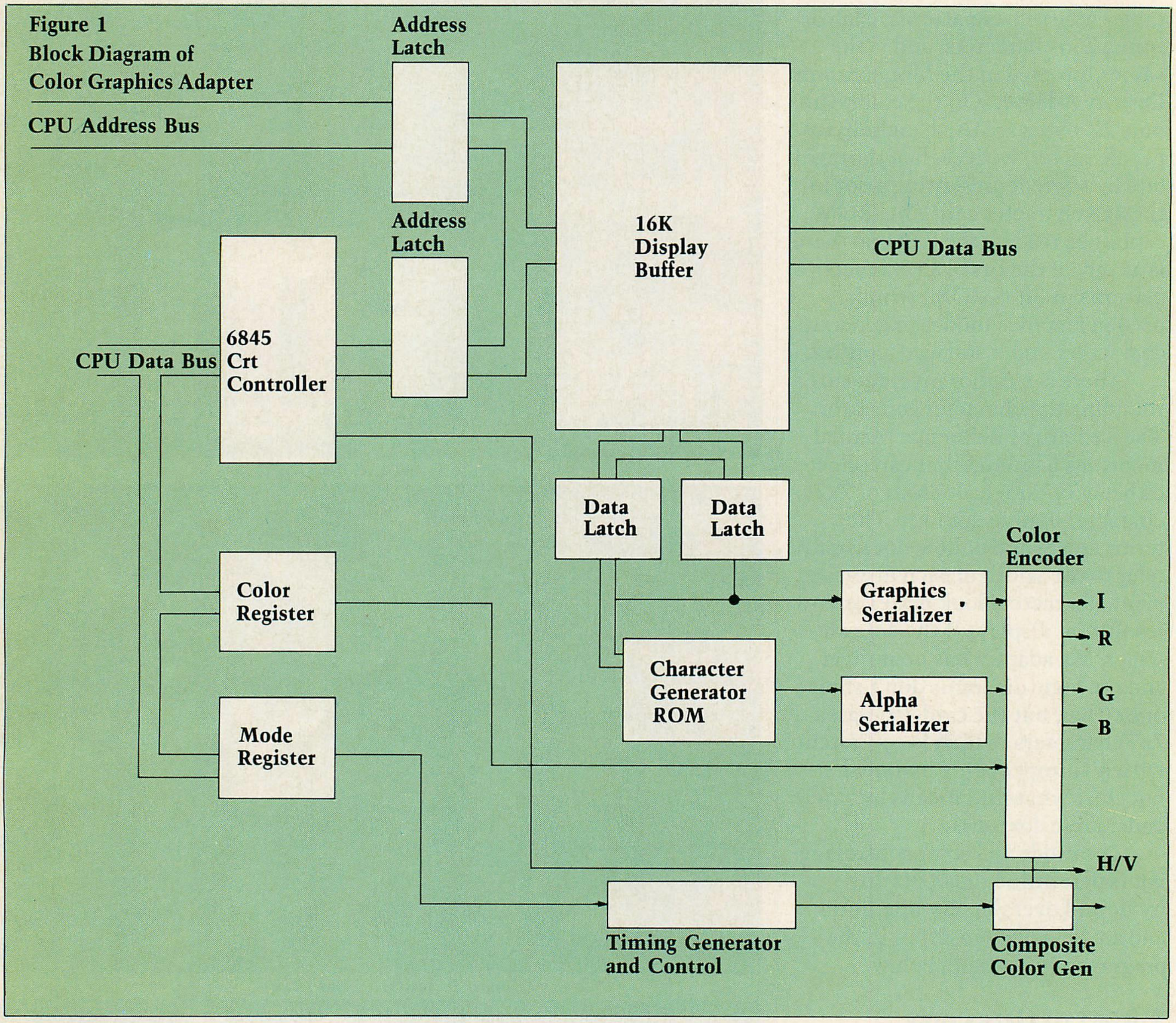


Figure 1
Block Diagram of
Color Graphics Adapter

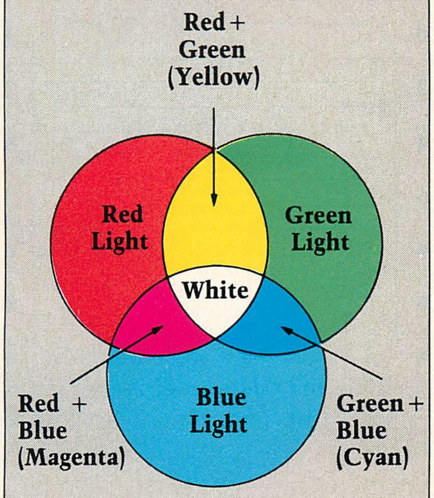
THE COLORS ARE DETERMINED BY INDEPENDENT BITS FOR EACH ADDITIVE PRIMARY COLOR—RED, GREEN, AND BLUE AND A FOURTH BIT FOR INTENSITY.

Alpha Mode

In alpha mode, each pair of bytes determines an 8x8 pixel region of the display. The first byte, which always has an even address, contains a character code that selects one of 256 patterns from the character generator ROM. The second byte called the attribute byte, determines the foreground color (used where the character generator pattern bits are '1') and background color (character pattern bits are '0') for the character.

The colors are determined by independent bits for each additive primary color—red, green, and blue—and a fourth bit for intensity. The three primaries can be mixed in eight combinations (see figure 2) to form the basic RGB colors. The intensity control gives an additional eight colors, each a brighter version of its non-intensified counterpart. Photograph 1 shows all 16 IRGB colors; table 1 shows the composition of each color.

Figure 2: Additive Color Mixing



The three additive primary colors, red, green, and blue, combine to form white light. In pairs they form the complementary colors cyan, magenta, and yellow. Black is the absence of any light.

The low order four bits of the attribute byte determine the foreground color, and the high order bits determine the background. The adapter may be programmed for the high order attribute bit to control either background intensity, allowing sixteen background colors on the screen simultaneously, or foreground blinking. Standard IBM software selects the blinking function, restricting the display to eight background colors. Table 2 shows the format of the character code and attribute bytes.

With two bytes per displayed character, a 40x25 display uses 2000 bytes and an 80x25 display uses 4000 bytes. The display 16K byte display buffer is thus big enough for either eight or four complete pages of text. Normally, the adapter displays characters starting from the beginning of the buffer, but the 6845 can be programmed to start at any even address. This can be used to scroll the display without moving data in memory or to switch rapidly to a new display.

Graphics Modes

In graphics modes, each pixel of the display is individually controlled by one or two bits, depending on the selected resolution. This is sometimes called "all points addressable" graphics, as opposed to the "alpha mosaic" or "character" graphics available in alpha modes. All images, even characters, are formed by individually programmed pixels. The PC's ROM BIOS contains a character generator table for the first 128 character codes with the same patterns as those in the color adapter's ROM. In graphics modes, the software must read the patterns from the table and turn on the appropriate pixels. To read characters back from the screen memory in graphics modes, the BIOS programs actually match the patterns in the display buffer against those in the character table to determine the character displayed.

The increased flexibility in displayable images comes at the price of more memory. For example, in high resolution 640x200 graphics mode, 64 bits are required for each 8x8 pixel character cell; in alpha mode, 8 bits indirectly specify the entire 8x8 pattern. Both resolutions use 16,000 bytes of display buffer to represent the screen image.

In high resolution graphics two colors can be displayed, but, like Henry Ford's Model T, one of them—used for border and background—is always black. The foreground is controlled by the color select register.

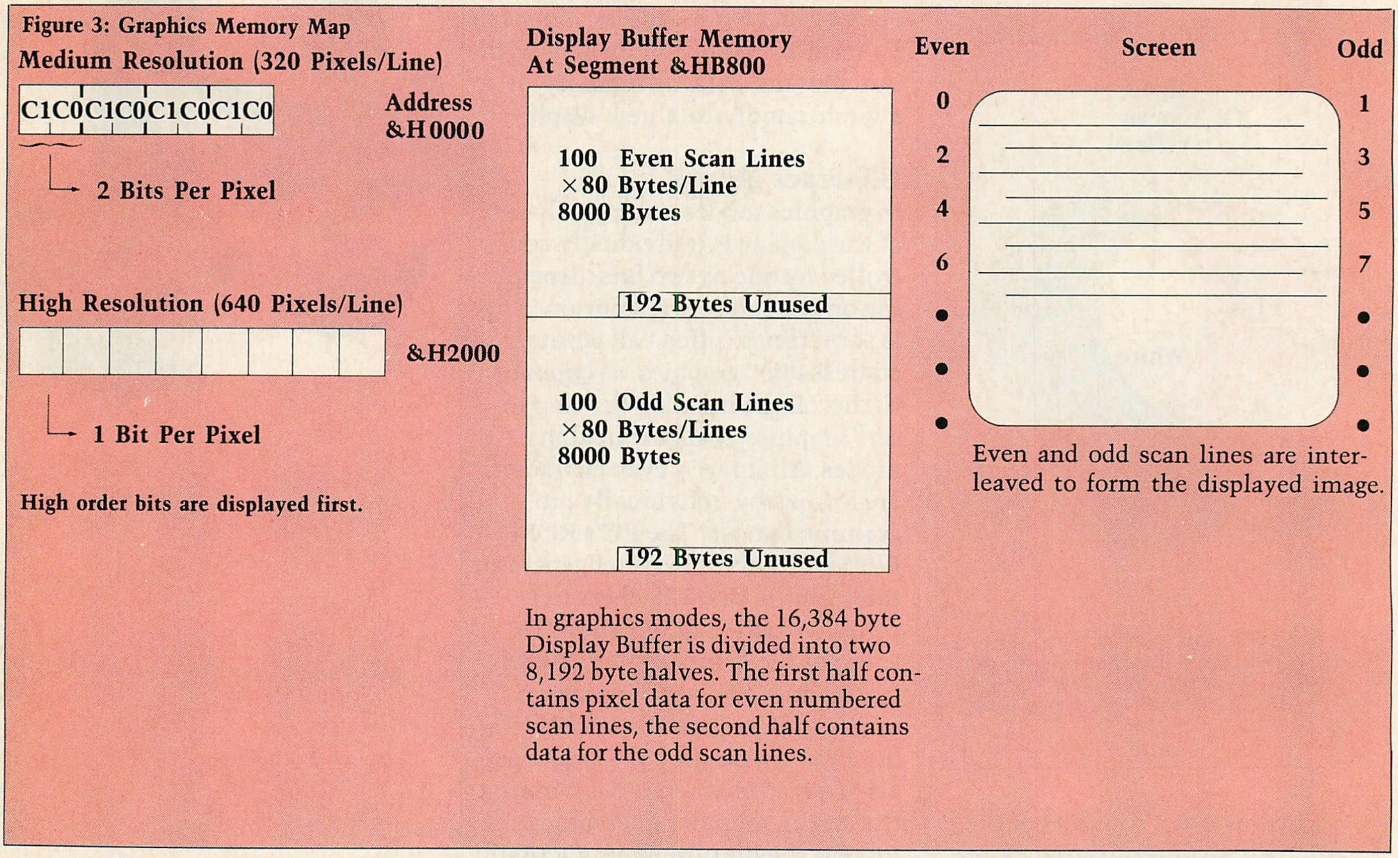


Figure 3: Graphics Memory Map

Medium resolution 320x200 graphics uses two bits per pixel, providing four colors. The background color, selected when both bits are 0, can be any one of 16 colors programmed into the background/border bits of the color select register. The other three colors are chosen from pre-selected color sets shown in table 3.

The display buffer is organized into two banks of 8K bytes each. Even numbered scan lines are displayed from the lower bank, odd numbered lines from the upper bank. This interleaving is unfortunate from the programmer's viewpoint, but results from a hardware/software tradeoff forced by the 6845's inability to address more than 128 character rows. This is explained more fully in the 6845 programming discussion.

Figure 3 summarizes the graphics memory map and pixel formats.

Programming the Color Graphics Adapter

In addition to the 16K display buffer memory, the adapter has several I/O ports through which its operation can be controlled and monitored. Table 4 summarizes the I/O device and bit assignments. Their operation is detailed below.

THE THREE PRIMARIES CAN BE MIXED IN EIGHT COMBINATIONS TO FORM THE BASIC RGB COLORS.

6845 Address Register (&H3D4)

This 5-bit write-only register is used to select one of the 18 internal data registers of the 6845 CRT controller by writing the register number to this port. The selected register is then read or written through the 6845 Data Register.

6845 Data Register (&H4D5)

This port is used to access the internal data register previously selected through the 6845 Address Register. The function of the various data registers is explained in the 6845 programming section below.

Mode Register (&H3D8)

The mode register is a 6-bit write-only register. Each bit controls one aspect of the operation of the display electronics, and together they establish the basic operating mode for the adapter. Table 5 summarizes the mode bits and standard settings for each of the IBM-supported video modes.

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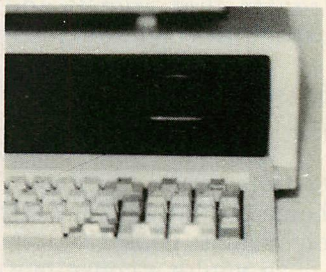

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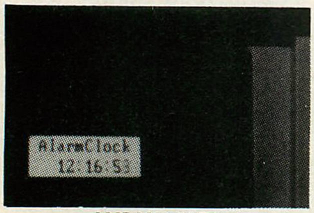

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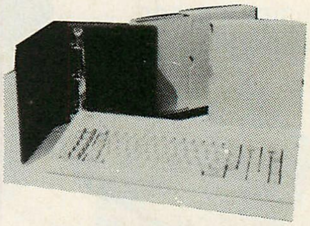

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Bit 0
High Resolution Dot Clock
Selects either a 7 or 14 megahertz dot clock, which determines both the rate at which dots from the character generator are sent to the screen, and when data is read from the display buffer. In alpha mode this selects 40 or 80 columns. A '1' selects the 14 MHz (80 column) clock.

Bit 1
Graphics Select
Selects between alpha and graphics modes. In alpha mode, successive bytes are interpreted as character code/attribute pairs, with the actual display patterns read from the character generator ROM. In graphics mode, pixels are directly determined by adjacent bits, or groups of bits, from successive bytes in the display buffer. A '1' selects graphics mode.

Bit 2
Black and White Select
Selects color or black and white mode for composite monitors or TV receivers. A '1' disables the color burst signal, giving a black and white image. With RGB monitors, this bit selects a variant color palette in 320x200 medium resolution graphics mode. Otherwise, this bit has no effect on RGB monitors.

Bit 3
Video Enable
Enables the video signal for the displayed area of the screen. When this bit is '0', the adapter's internal registers, which contain pixel or character and attribute data, are forced to '0', thus turning off the video signal. IBM suggests disabling the display when changing modes or reprogramming the 6845 CRT controller. A '1' enables the video signal. This bit does

Table 1 — Standard I-R-G-B Colors

Color Number	I R G B	Color Name	Composition
0	0 0 0 0	Black	
1	0 0 0 1	Blue	Blue
2	0 0 1 0	Green	Green
3	0 0 1 1	Cyan	Green + Blue
4	0 1 0 0	Red	Red
5	0 1 0 1	Magenta	Red Blue
6	0 1 1 0	Brown	Red + Green
7	0 1 1 1	White (Light Gray)	Red + Green + Blue
8	1 0 0 0	Dark Gray	Int
9	1 0 0 1	Light Blue	Int + Blue
10	1 0 1 0	Light Green	Int + Green
11	1 0 1 1	Light Cyan	Int + Green + Blue
12	1 1 0 0	Light Red	Int + Red
13	1 1 0 1	Light Magenta	Int + Red + Blue
14	1 1 1 0	Yellow	Int + Red + Green
15	1 1 1 1	Intense White	Int + Red + Green + Blue

Table 2 — Character Code/Attribute Formats

In alpha modes, each display position is defined by a character code/attribute pair. The character code is always the even-addressed byte, the attribute is the next higher odd-addressed byte.

Character Code Byte
7 6 5 4 3 2 1 0

Attribute Byte

7	6	5	4	3	2	1	0
I/BL	Red	Grn	Blu	I	Red	Grn	Blu
	Background					Foreground	

Attribute Byte Format

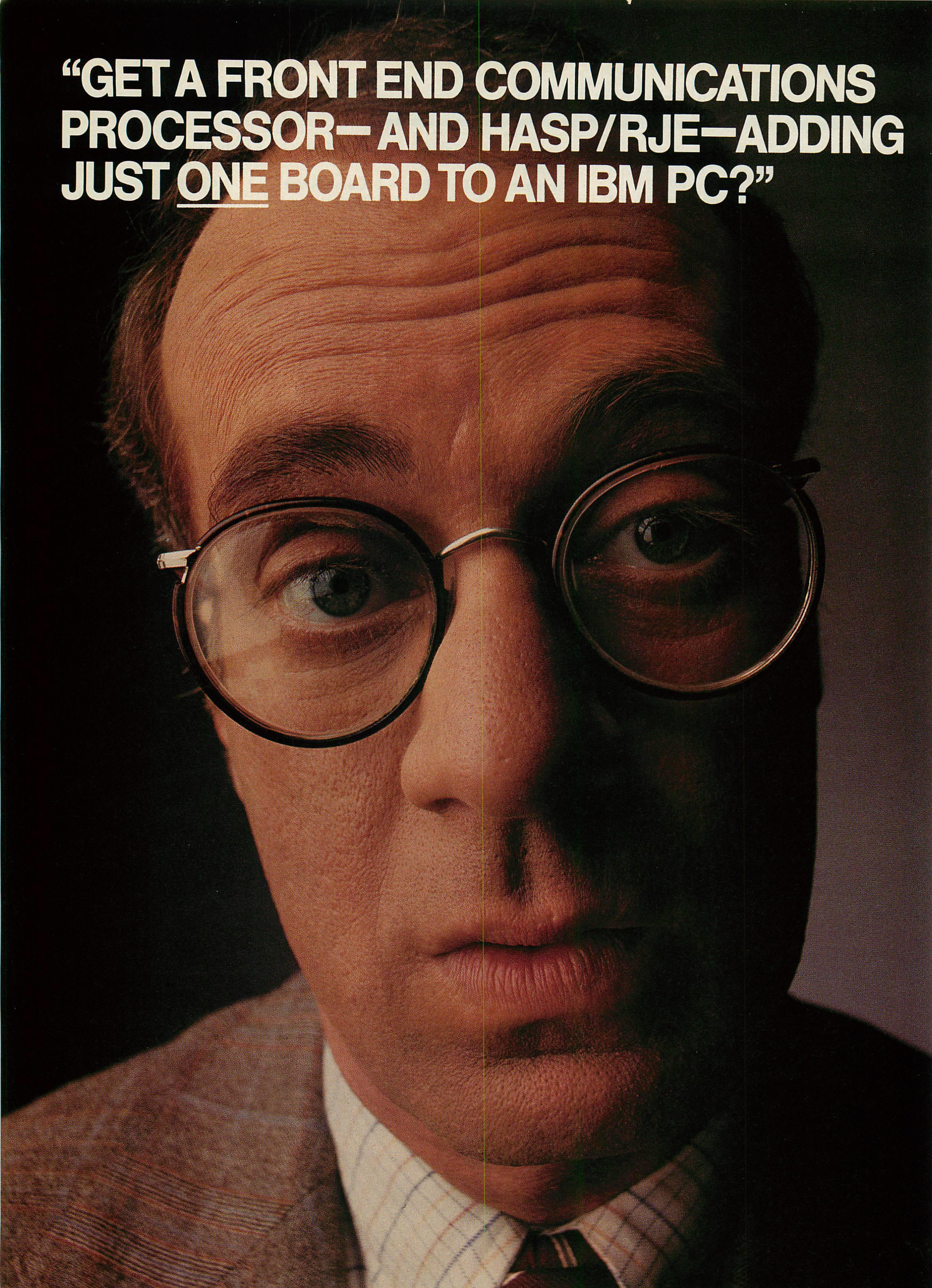
Bits 0-3	Foreground Color
Bits 4-6	Background Color
Bit 7	Background Intensity (Mode Bit 5 = '0') or Foreground Blink (Mode bit 5 = '1')

The COLOR statement in BASIC establishes the foreground, background, and border colors. Border color is changed immediately; foreground and background take effect for subsequently displayed characters.

COLOR [foreground] [,[background] [,border]]

Foreground may be 0 to 31, and sets attribute bits 7 and 0-3.
Background may be 0 to 7 and sets attribute bits 4-6.
Border may be 0-15, and sets bits 0-3 of the color select register.

THE DESCRIPTIONS IN THE IBM TECHNICAL REFERENCE MANUAL DON'T PROPERLY EMPHASIZE THE INDEPENDENCE OF EACH MODE BIT FROM THE OTHERS.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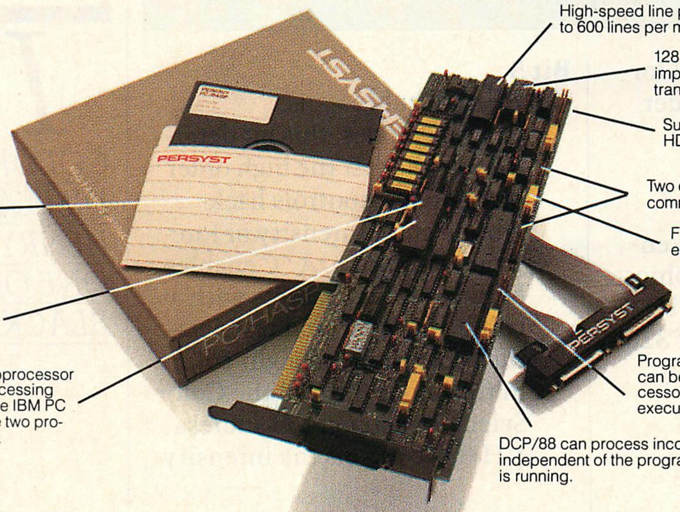

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Table 3 — Medium Resolution (320 × 200) Color Sets

Colors in medium resolution are formed by combining bits from the color select register with the two pixel bits — C1 and C0 — from the display buffer. When C1 and C0 are both '0', the background color is displayed from CSR bits 0-3.

CSR Bit 4 (Int)	Pixel Data C1 (Red)	C0 (Green)	CSR Bit 5 (Blue)	IRGB Color Number	Color Name
(0)	0	0	(0)	??	Background
0	0	1	0	2	Green
0	1	0	0	4	Red
0	1	1	0	6	Brown
(1)	0	0	(0)	??	Background
1	0	1	0	10	Light Green
1	1	0	0	12	Light Red
1	1	1	0	14	Yellow
(0)	0	0	(1)	??	Background
0	0	1	1	3	Cyan
0	1	0	1	5	Magenta
0	1	1	1	7	White
(1)	0	0	(1)	??	Background
1	0	1	1	11	Light Cyan
1	1	0	1	13	Light Magenta
1	1	1	1	15	Intense White

In medium resolution black and white graphics modes (mode register bit 2 set to '1'), RGB monitors will display the following colors.

CSR Bit 4(Int)	Pixel Data C1 Red	CO (Green)	(Blue)	IRGB Color Number	Color Name
(0)	0	0	(0)	??	Background
0	0	1	1	3	Cyan
0	1	0	0	4	Red
0	1	1	1	7	White
(1)	0	0	(0)	??	Background
1	0	1	1	11	Light Cyan
1	1	0	0	12	Light Red
1	1	1	1	15	Intense White

Note: Bit values in parentheses have no effect on the background color.

not affect the video signal for displaying the screen border area.

Bit 4

640 Dot Graphics

In conjunction with bit 1, enables high resolution graphics, with one bit per pixel. A '1' selects 640 1-bit pixels, a '0' 320 2-bit pixels per line.

Bit 5

Blink Enable

In alpha modes, this bit determines whether the high order attribute bit controls background color intensity or foreground blinking. A '1' enables blinking for characters with attribute bit 7 set, and restricts the background to eight colors. In this mode, bit 4 of the Color Select Register at I/O address &H3D9 controls the intensity of all background colors. A '0' inhibits blinking and allows all 16 background colors. This bit has no effect in graphics modes (i.e., when bit 1 is '0').

The descriptions above differ slightly from those in the IBM Technical Reference Manual, which don't properly emphasize the independence of each mode bit from the others. For example, IBM calls bit 0 the "80 x 25 mode alpha mode" bit, presumably because it is one of the bits that must be set to achieve that mode. But bit 0 does not determine alpha versus graphics, and none of the mode bits have anything to do with the number of lines displayed: that's determined by the 6845.

IBM's version is no doubt well-intentioned; after all, "80 x 25" makes more sense to most people than "high resolution dot clock," but it can lead to misunderstandings about how the adapter works.

COLOR SELECT REGISTER (&H3D9)

This 6-bit write-only register controls the screen border color in alpha modes, background color and foreground color set in medium resolution (320x200) graphics modes, and the foreground color in high resolution (640x200) graphics modes.

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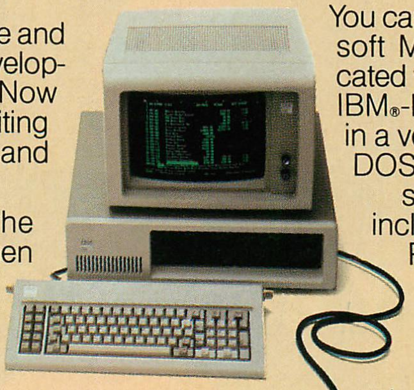

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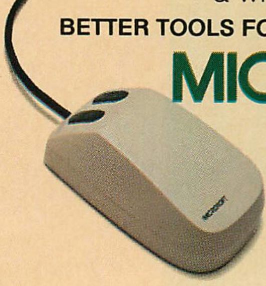

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Bits 0-3

Alpha border, 320 Background, 640 Foreground

In alpha modes, these bits determine the color of the screen border area. In 320x200 graphics, they select the background color displayed for pixel values of '00'. In 640x200 graphics, they select the foreground color displayed for pixel values of '1'. The background and border are always black in high resolution graphics modes. The bits are arranged in the same order as the color attribute bits in alpha mode:

Bit	3	2	1	0
	Intensity	Red	Green	Blue

Bit 4

Alpha Background / 320 Graphics Foreground Intensity

This bit selects the intensity for background colors in alpha mode when blink is enabled (mode register bits 1 and 5 are both '0'). In medium resolution (320 pixel) graphics, this bit controls the intensity of the foreground color set.

Bit 5

Medium Resolution Graphics Color Set (Blue Control)

Determines the color set used for foreground colors in medium resolution (320x200) graphics by controlling the presence or absence of blue. Red and green are selected by the high and low order bits of the pixel — C1 and C0, respectively. The resulting combinations are shown in table 3. Bit 5 has no effect in modes other than medium resolution graphics.

Table 4 — Color/Graphics Adapter I/O Devices

I/O Port Address	Device Name	Read/Write	Active Data Bits
&H3D4	6845 Address Register	W	- - - 4 3 2 1 0
&H3D5	6845 Data Register	R/W	- - - 4 3 2 1 0
&H3D8	Mode Select Register	W	7 6 5 4 3 2 1 0
&H3D9	Color Select Register	W	- - 5 4 3 2 1 0
&H3DA	Status Register	R	- - - - 3 2 1 0
&H3DB	Clear Light Pen Latch	R/W	- - - - - - - -
&H3DC	Set Light Pen Latch	R/W	- - - - - - - -

Mode Register (&H3D8)

Bit	Function
Bit 0	High Res Dot Clock (80 Character alpha)
1	Graphic Select
2	Black & White Select
3	Enable Video
4	640 Graphics Select
5	Alpha Blink Enable

Color Select Register (&H3D9)

Bit		
Bit 0	Blue	Alpha Border/Graphics Background
1	Green	Alpha Border/Graphics Background
2	Red	Alpha Border/Graphics Background
3	Intensity	Alpha Border/Graphics Background
4	Intensity	Alpha Background/Medium Resolution Foreground
5	Medium Resolution Foreground Color Select (Blue)	

Status Register (&H3DA)

Bit	Function
Bit 0	Display Inactive
1	Light Pen Trigger Set
2	Light Pen Switch Open
3	Vertical Sync

Notes: 1. The 6845 also responds to other even/odd I/O addresses in the range &H3D0 to &H3D7. The addresses shown are the recommended standard used by all IBM software.

2. The 6845 Data Register may have from 4 to 8 active bits, depending on the internal register selected by the 6845 Address Register.

3. The Clear and Set Light Pen functions are activated by any I/O read or write to the appropriate port.

STATUS REGISTER (&H3DA)

This 4-bit read-only register provides two signals for monitoring the video timing, and two for the light pen interface.

Bit 0

Display Inactive

This bit is the inverted display enable bit from the 6845 CRT controller. It is '1' during the horizontal and vertical blanking intervals, and '0' during the active display interval. When this bit is '1', CPU accesses to the display buffer will not interfere with the display. When the high resolution dot clock is selected, as in 80 column alpha mode, unsynchronized direct access to the display buffer can cause "snow" in the picture if the display is enabled.

(continued on page 45)

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(continued from page 41)

Bit 1

Light Pen Trigger Set

When '1', this bit indicates the light pen trigger has been set. The buffer memory address at the time the trigger was set can be read from the 6845 light pen register. This bit can be set by the light pen input going high or by an OUT to port &H3DC. It can be reset by an OUT to port &H3DB.

Bit 2

Light Pen Switch Status

This bit shows the state of the light pen switch. A '1' means the switch is open, a '0' means it is closed.

Bit 3

Vertical Sync

This bit can be used to synchronize with the start of a vertical retrace, which begins each field 60 times per second. It is used in diagnostics (along with bit 1) to check that the video timing signals are being generated correctly. A transition from '0' to '1' marks the beginning of the vertical sync pulse.

LIGHT PEN LATCH RESET (&H3DB) AND SET (&H3DC)

Any output to these ports—the data doesn't matter—resets or sets the light pen latch as indicated. The latch must be cleared before the 6845 can read the light pen again. These ports can also be used to fake light pen input, either for diagnostic purposes or to synchronize a program with the display refresh.

Table 5 — Standard Video Models

Mode Register (&H3D8)

BIOS Mode	Description	Bit 5 Blink Enable	4 640 Dot Graphics	3 Enable Video	2 B/W	1 Graphics	0 Hight Res	Hex	Dec
0	40 × 25 Alpha B/W	1	0	1	1	0	0	2C	44
1	40 × 25 Alpha Color	1	0	1	0	0	0	28	40
2	80 × 25 Alpha B/W	1	0	1	1	0	1	2D	45
3	80 × 25 Alpha Color	1	0	1	0	0	1	29	41
4	320 × 200 Graphics Color	(1)	0	1	0	1	0	2A	42
5	320 × 200 Graphics B/W	(1)	0	1	1	1	0	2E	46
6	640 × 200 Graphics B/W	(0)	1	1	1	1	0	1E	30

To set these modes from BASIC, the following statements can be used:

BIOS Mode	BASIC Statement(s)
0	SCREEN 0,0: WIDTH 40
1	SCREEN 0,1: WIDTH 40
2	SCREEN 0,0: WIDTH 80
3	SCREEN 0,1: WIDTH 80
4	SCREEN 1,0
5	SCREEN 1,1
6	SCREEN 2

Notes: 1. Mode 1 or 3 is selected by default at power on, depending on the setting of switches 1-5 and 1-6 on the system board.

2. Bit 5 (blink enable) has no effect in graphics modes. The values shown for modes 4, 5, and 6, are those actually written to the mode register by BIOS.

3. BIOS saves the current mode register and color register values in segment 0, location &H465 and &H466, respectively. value in.

4. The color register is initialized to &H30 for modes 0 to 5, and to &H3F for mode 6. This results in white foreground against a black background.

STANDARD OPERATING MODES

Let's look at the seven standard operating modes supported by IBM for the Color/Graphics Adapter. Table 5 shows the four alpha and three graphics modes, numbered as they are for the BIOS video I/O Set Mode function (interrupt &H10, AH = 0, AL = mode number) and the associated contents of the CGA mode register.

The mode register values for the standard modes are easily understood as straightforward combinations of the bits that specify the desired features. The major decisions are graphics or alpha (bit 1), and color or black and white (bit 2). In graphics mode we must further select 320 or 640 pixels per line (bit 4). In alpha mode we must choose between 40 or 80 columns per line (bit 0), and 8 background colors with blinking characters or 16 background colors with no blinking (bit 5).

How many modes are there? There are 64 possible combinations of the six mode bits, but half of them have video enable (bit 3) turned off. Of the 32 remaining visible combinations, half are alpha and half are graphics. Of the 16 possible visible alpha combinations, the 8 with 640 dot graphics turned

Table 6 — 6845 Data Register Summary

Register	R/W	Units	Programmed Value	Max Value
00 H. Total	W	Char	Total chars-1	255
01 H. Displayed	W	Char	NR displayed	255
02 H. Sync Pos.	W	Char	Nr chars to sync	255
03 H. Sync Width	W	Char	Nr char	15
04 V. Total	W	Char Row	Total rows-1	255
05 V. Adjust	W	Scan Line	Nr scan lines	31
06 V. Displayed	W	Char Row	Nr rows	127
07 V. Sync Pos.	W	Char Row	Nr rows to sync	127
08 Interlace Mode	W	---------	(Note 1)	3
09 Max Scan Line	W	Scan Line	Lines per row-1	31
10 Cursor Start	W	Scan Line	First line (Note 2)	127
11 Cursor End	W	Scan Line	Last line	31
12 Start Addr (H)	W	---------	High 6 bits (Note 3)	63
13 Start Addr (L)	W	---------	Low 8 bits	255
14 Cursor Addr (H)	R/W	---------	High 6 bits (Note 3)	63
15 Cursor Addr (L)	R/W	---------	Low 8 bits	255
16 Light Pen (H)	R	---------	High 6 bits (Note 3)	63
17 Light Pen (L)	R	---------	Low 8 bits	255

Notes:

1. Interlace modes 0 and 2 are non-interlace. Mode 1 is interlace sync (duplicates data on even and odd fields). Mode 3 is interlace sync and video (even scan lines displayed on even fields, odd scan lines on odd fields).

2. Bits 0-4 specify first scan line. Bits 5 and 6 control cursor display and blinking as follows:

Bit 6	5	Cursor Display Mode
0	0	Non-blinking cursor
0	1	Cursor not displayed
1	0	Cursor blinks rapidly (1/16 field rate)
1	1	Cursor blinks slowly (1/32 field rate)

The color adapter has its own external cursor blinking logic, so in practice bit 6 should always be programmed to '0'. Bit 5 can be used to disable the cursor display.

3. These registers are paired to form a 14 bit display buffer address. This address is one half of the address of the even (character code) byte in each character/attribute pair.

OF THE 16 POSSIBLE VISIBLE ALPHA COMBINATIONS, THE 8 WITH 640 DOT GRAPHICS TURNED ON DON'T TURN OUT TO BE USEFUL. TRY IT, YOU'LL SEE.

on don't turn out to be useful (try it—you'll see). The blink enable bit has no effect in graphics mode, so only eight real graphics modes remain. Total sensible combinations: eight alpha and eight graphic. So why does IBM only have seven modes? Where are the other nine? What are they hiding?

The four IBM alpha modes all have blink enabled, for "normal operation." To get the other four, the mode register must be set directly to turn off bit 5. Since BIOS saves the value written to the mode register in absolute location &H465, it's easy enough to read it, change it, put it back, and output it. The following BASIC program does just that.

```
10 '--Change Alpha Mode to
   Non-Blink
15 '-- 16 Background Colors
20 MODESAVE = &H465
25 MODEREG = &H3D8
30 BLINKENABLE = &H20
35 DEF SEG = 0
40 SCREEN 0,1 '--Set Alpha
   Color
45 MODE = PEEK (MODE-
   SAVE) AND NOT
   BLINKENABLE
50 POKE MODESAVE, MODE
55 OUT MODEREG, MODE
```

It's good practice to keep the MODESAVE location up to date when experimenting with non-standard modes, because BIOS will sometimes restore the mode register from that location when you're not expecting it. One such time is when CTRL-NumLock is pressed to pause execution of a program. If MODESAVE isn't correct, you may find the display back in the last "standard" mode.

What about "secret" graphics modes? Four of the eight combinations have the high resolution dot clock (bit 0) set. In alpha mode this bit means 80 columns are displayed, requiring 160 bytes from the display buffer for each line (80 character code/attribute pairs). In graphics mode the same 160 bytes are fetched, effectively doubling the number of pixels per line. Unfortunately, twice as many pixels on each of the 200 lines would require 32K bytes of buffer memory, which the adapter doesn't have.

That leaves us with four useful graphics modes, where IBM supports three. The missing combination is 640 by 200 *color* graphics. Can the adapter really do that? The answer is a qualified yes.

(continued on page 135)

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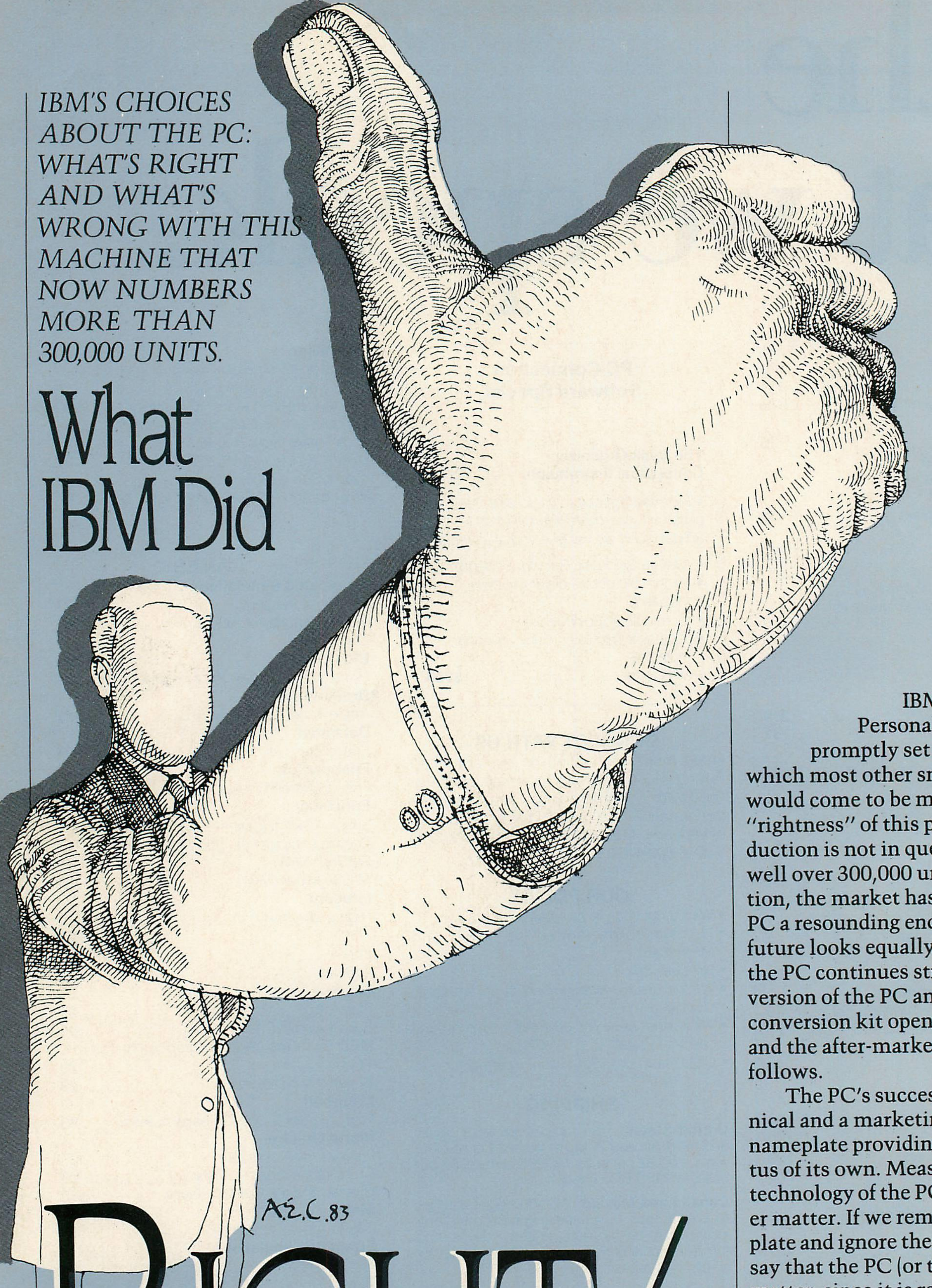


ALAN E. COBER

Almost two years ago, IBM introduced its Personal Computer and promptly set the standard by which most other small computers would come to be measured. The "rightness" of this product introduction is not in question: with well over 300,000 units in circulation, the market has given the IBM PC a resounding endorsement. The future looks equally bright for IBM: the PC continues strong, the "XT" version of the PC and the 3270 PC conversion kit open new horizons, and the after-market rapidly follows.

The PC's success is both a technical and a marketing one, with the nameplate providing a strong impetus of its own. Measuring just the technology of the PC is quite another matter. If we remove the nameplate and ignore the success, can we say that the PC (or the XT for that matter, since it is really the same machine) is a technologically sophisticated or advanced system? The answer is no, and the examination leading to this conclusion provides some interesting and valuable insights.

Particularly intriguing is the fact that a given item of discussion about the PC can yield both positive and negative conclusions. In these cases, we try to understand the rationale of IBM as they made their original design decisions. And because of such cases, it is hard to simply divide the good and the bad into two columns and proceed: both sides of the coin must be observed together (we'll do it with mirrors).

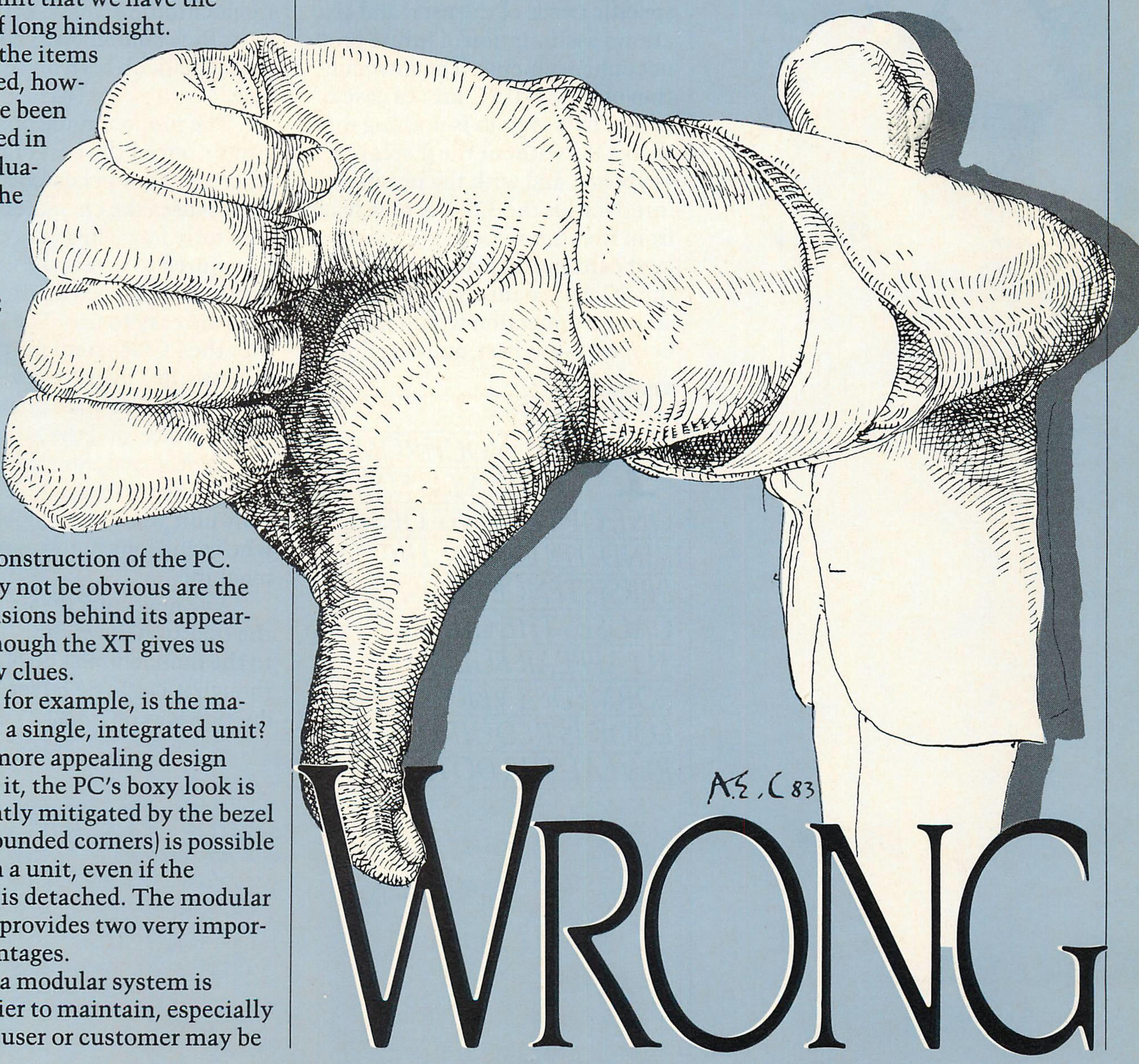
Before we begin, we must not fail to admit that we have the benefit of long hindsight. Many of the items considered, however, have been mentioned in early evaluations of the PC.

The Outside

It may seem trivial to discuss the appearance and general construction of the PC. What may not be obvious are the right decisions behind its appearance, although the XT gives us some new clues.

Why, for example, is the machine not a single, integrated unit? A much more appealing design (let's face it, the PC's boxy look is only slightly mitigated by the bezel and the rounded corners) is possible with such a unit, even if the keyboard is detached. The modular approach provides two very important advantages.

First, a modular system is much easier to maintain, especially when the user or customer may be



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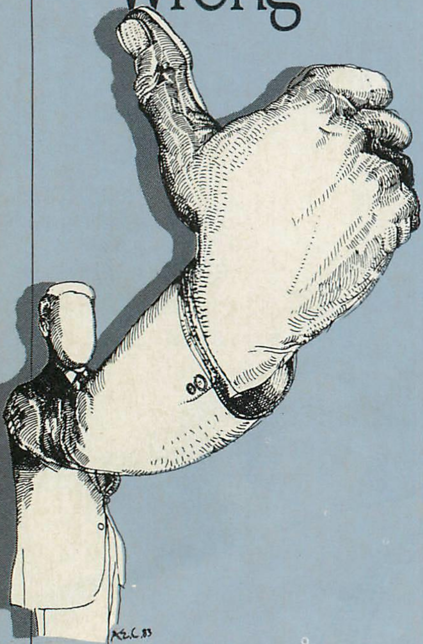


relied upon to return the defective part for service. Giving the user a way to diagnose the problem and isolate the failing part allows the service organization to avoid having to deal with the entire system. Furthermore, the contact organization, the one to whom the user delivers the broken part, can replace the entire unit immediately and return the broken part to a depot for repair. The user's system is thus operational quickly, while the cost to the servicing organization is minimized.

Second, a modular system is more flexible. It allows easier configuration of a system to meet the specific needs of the user, and also allows assimilation of future product enhancements. The introduction of the 3270 PC kit is a case in point. This system is nothing more than a PC without the display or keyboard, and with the necessary interface for the 3270. A plug leads from that interface to both the keyboard and display connectors on the PC. For an integrated unit, such an interconnection would have been messy at best, and certainly would have resulted in redundant components. Another obvious example is the choice of color versus monochrome display. The modularity of the PC allows either type of display device to be placed on top of the system unit. IBM is also free to introduce new displays as technological developments and cost permit without having to introduce an entirely new model of the computer. IBM's new color monitor bears this out, as does the availability of a large number of display monitors from third parties.

THE MONOCHROME DISPLAY IS SIMPLY ONE OF THE BEST OF ITS KIND. ITS GREEN, HIGH-PERSISTENCE PHOSPHOR CAUSES THE CHARACTERS TO APPEAR FULLY FORMED; A VERY CLOSE LOOK IS REQUIRED TO REVEAL THE DOTS.

Displays

Until recently, IBM offered only the monochrome display. Early this year, they announced a color display. Chalk up both on the right side.

The monochrome display is simply one of the best of its kind. Its green, high-persistence phosphor causes the characters to appear fully formed; a very close look is required to reveal the dots. The controls are placed up front where they are easy to use. The unit plugs into the PC's system unit and thus is controlled by the master PC on/off switch. The screen has an antiglare surface, and the face of the tube is recessed from the front of the unit to further reduce glare. This unit was designed for those who spend long hours in front of the machine.

The new color display follows the tradition. Its styling is similar to the monochrome display, although it is a little larger. Glare reduction was obviously a design

goal, but the screen is shinier and glare is more apparent than on the monochrome. It does not plug into the system unit and thus requires an additional receptacle; it has its own power switch, conveniently mounted on the front. Its quality as a color display is very high. The colors are superb (brown and gray really are); the screen is eerily black.

Both IBM displays are high-quality, well-designed units.

The Keyboard

The keyboard is the single most maligned component of the IBM Personal Computer. It is deserving of this reputation.

The keyboard has many excellent characteristics. The keys have a nice feel and are obviously of above average quality. The unit is heavy and tends to stay where it is put. The "pencil ledge" is useful for resting books or papers, especially if the keyboard can be mounted two inches below the system unit.

After that it's downhill all the way. The worst feature is the placement of the backslash (\) key where the left shift key is expected. This, coupled with the small size of the shift keys and the unfortunate placement of the Alt and Caps Lock keys, makes for great typing difficulty for those with experience on other computers or even an IBM Selectric typewriter. IBM has not provided an adequate explanation for this serious design flaw, which continues with the new XT.

The size of the keytop for certain other keys is another drawback. The ENTER key (aka RETURN or NEWLINE) is tiny compared to its cousins on other keyboards. The same holds for the TAB key. The Num Lock and Scroll keys, as well as the plus (+) key on the far right of the keyboard, are bigger than they need be given their relatively light use. In fact, a better arrangement for the numeric keypad would have been a small plus key just below the minus key, with a double-sized ENTER key just below it. For key entry of numerical data, the extra ENTER key would really help.

And, of course, there are the function keys to the left. Even though the pencil ledge is nice, those function keys belong in a row along the top. They are in an awkward place, especially for programs that attempt to use all four combinations (unshifted, shifted, control, Alt). The control and Alt combinations usually require the right hand for the Alt key while the left strikes the desired function key, thus removing the hands quite far from the normal typing position.

The absence of indicator lamps for Caps Lock and Num Lock is another oft-heard complaint. The reason for this is almost certainly a firmware issue. We can guess that IBM wished to keep the keyboard as "soft" as possible, and lights in keys tend to reduce their functional flexibility. Perhaps a better choice would have been a bank of, say, five indicator lights near the upper right corner of the keyboard. A template could surround them, and they could be redefined under software control just as the function keys now are. The Caps and Num Lock functions would be defined by the system as its default.

This author prefers the layout of almost every other recently introduced small computer keyboard over the PC. This author also prefers the feel (and the clack) of the IBM keyboard, as well as its compact size. Why can't a keyboard be both? All things considered, the keyboard could use some work.

The Printer

IBM's choice of the Epson printer is almost right on the money. The visible indicator of this is the remarkable decline in the price of a maintenance contract for it. Originally \$179 per year, the cost is now \$68. This author knows no one who has opted for the contract: The Epson printer just never breaks.

Nonetheless, IBM made some poor decisions regarding the printer. The original IBM offering (model 5152001) did not include the graphics option, a clear mistake, and was greatly over-priced. The new model (5152002) does have graphics, and at \$595 is more competitively priced. Neither model supports friction feed, which is sad, but the sleek MX-80 has a far better appearance than the F/T models. Perhaps aesthetic considerations drove IBM's choice.

THE KEYBOARD IS THE SINGLE MOST MALIGNED COMPONENT OF THE IBM PERSONAL COMPUTER, AND IT IS DESERVING OF THIS REPUTATION.

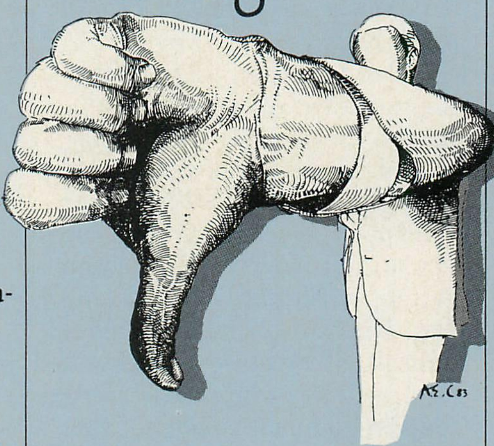
At the same time, the Epson was the best choice. It is surprising that no improved model has surfaced from IBM because there are quite a few very nice printers available now in the same general price range. Most of these are faster and more functional than the MX-80. Perhaps IBM has been waiting for the recent introduction of the FX-80 (160 cps, much more versatile) for their own next printer announcement.

What's inside the printer is important too. The current Epson models (designated III) include "Graphtrax-Plus" as a standard feature. This ROM set incorporates a new program which is compatible with the old Graphtrax but adds new features. The IBM model has most of these features, but the code to support italics has evidently given way to an implementation of the IBM character set with all the line drawing characters. Printing in italics is very useful, but so is the character set. As with the keyboard, we can't quite seem to have everything. Again, maybe the FX-80 with its 12K ROM capacity and 2K RAM will provide IBM with a better model.

The presence of the character set is a clue that IBM is trying to cut out the competition and sell more printers. The ROM set for the IBM printer is obviously different than the standard MX-80 III Graphtrax-Plus, and is only available inside IBM printers. Since the price is reasonable, it becomes easy to go IBM.

The character set, while an important improvement, deserves one criticism: it is not the full IBM PC set. There are a few characters that the printer *cannot* print, a situation perhaps related to the way the Epson decodes its commands. Again the question "Why not everything?" springs to mind.

IBM does not (yet?) have a letter-quality printer in the PC product line. The NEC printer is sold by IBM, and seems to be supported by many programs.



The Inside

The IBM PC's system unit is the "mother lode" of things to write about. It also represents the main reason why the IBM PC can be labeled "not technologically advanced."

We will first consider the system board, then peripherals, and finally software, including the ROM-resident programs.

The System Board

Central to the system board (actually, it's out on a corner) is the Intel 8088 microprocessor. IBM's choice of the 8088 was their most significant technical decision, and the most controversial. They chose correctly.

The 8088 is not particularly advanced even by the standards at the time it was chosen. Both the Motorola 68000 and the Zilog Z8000 offer more elegant, advanced architectures and are inherently more powerful. Many experts sniffed at the PC at the time of its introduction

THE IBM PC'S SYSTEM UNIT IS THE "MOTHER LODE" OF THINGS TO WRITE ABOUT. IT ALSO REPRESENTS THE MAIN REASON WHY THE IBM PC CAN BE LABELED "NOT TECHNOLOGICALLY ADVANCED."

for this very reason. Why, then, did IBM make the right choice?

The 8088 must have been compelling to IBM for a number of business and technical reasons. First, the 8088 provides a high degree of instruction set compatibility with the 8085 and Z80 processors. 8085 assembly language programs can even be directly translated to the 8088 with a very high probability that the converted program will run, while Z80 programs can come close. This compatibility meant that existing software could be ported to the PC quickly, and that is exactly what happened with some of the earlier programs. More significantly, however, and in keeping with IBM's conservative tradition, the 8088 is compatible with the support circuitry developed for the 8085 family. These circuits were proven parts, low in cost. The economies of assembling an 8-bit 8088 system over any 16-bit system (8086 included) were, and continue to be, attractive. The advantage the 8088 holds over every other available 8-bit system is complete software compatibility with its 16-bit sibling, the 8086, as well as the new line of chips from Intel (80188, 80186, 80286).

The low cost of electronics for the basic system also has an effect on the cost of the memory subsystem, as well as peripheral adapter cards. Because memory is accessed in parallel, the 8088 requires a bank of eight chips (plus a ninth for parity), each contributing one bit to the eight-bit byte. Memory can thus be built in increments of nine-chip banks. An 8086, or any other system requiring memory access to 16-bit quantities, needs banks of 16 chips (or 17 with parity or 21 with ERCC). The rapid price decline in memory chips (brought on by the 64K RAM price war) had just begun at the time the IBM system board was designed; using 64K RAMs or a 16-bit data path would have caused a noticeably higher system price.

Still, IBM was probably too conservative with the original PC. The new XT and the revised PC, both using 64K chips and having a system board memory capacity of 256KB, represent what should have been done in the first place. The rapidity with which other manufacturers came to market with memory expansion boards for the PC indicates that the time for 64K chips was right. Since a large proportion of the tasks to which IBM PCs have been put require more than 64KB of main memory (either for large programs or large data spaces), the PC's stinginess with memory to date has been a real problem for users and software developers alike.

The system board also contains additional circuitry to control the overall operation of the processor. Here again, IBM chose standard, available parts that were known, field-proven, reliable, and low in cost. This is certainly a decision that we would call correct: it results in increased system reliability, low infant mortality, and economy. Parts in this category are the 8284A clock generator, 8288 bus controller, 8259A interrupt controller, 8255A I/O ports, 8253-5 timer, and 8237A-5 DMA controller.

STILL, IBM WAS PROBABLY TOO CONSERVATIVE WITH THE ORIGINAL PC. THE NEW XT AND THE REVISED PC, BOTH USING 64K CHIPS AND HAVING A SYSTEM BOARD MEMORY CAPACITY OF 256KB, REPRESENT WHAT SHOULD HAVE BEEN DONE IN THE FIRST PLACE.

Besides the processor, its memory, and the control circuitry, there are three other elements on the system board: the cassette tape interface, the speaker, and the "socket."

The cassette tape is silly in retrospect. The number of IBM PC's sold without diskette drives is very small, but the clearer signal is the amount of software on tape: none. IBM may have thought that minimally configured PC's would find their way into the home market, but it is more likely that the home market went to smaller machines based on tape or demanded disk on bigger ones. The cassette port vanished on the XT, although the standard PC still includes it. IBM appears to have made a bad guess on

THIS WRITER PREDICTS THAT THE 8087 WILL BE A "MID-LIFE KICKER," SOMETHING TO PEP UP THE STANDARD PC IN THE FACE OF EVER MORE POWERFUL COMPETITION.

What IBM Did Right/Wrong

this, or else they were being very shrewd by making the PC *appear* to be a home machine.

By contrast, the speaker is important. IBM could have opted for a simple beeper, something that would give off only one sound, since that is typical of terminals in the business market. Instead, the speaker allows a wide range of sounds, and even some limited voice synthesis. What is perhaps not widely recognized is the value of aural input. The ability to program a variety of sounds allows the system developer to give non-visual cues that can be distinguished from one another. Such cues have wide application. Of course, the flexibility of a speaker also enhances games, although the PC is limited to a single voice.

The most exciting part of the system board is the empty 40-pin socket, immediately recognized by almost every engineer as the place for the Intel 8087 numeric co-processor. IBM has still not officially acknowledged this fact, and has made no offering to support it. A number of third-party manufacturers sell the chip and software to support it, and most language suppliers offer 8087 routines in their libraries, if not in the generated code. This writer predicts that the 8087 will be a "mid-life kicker," something to pep up the standard PC in the face of ever more powerful competition. The 8088/8087 combination is quite powerful, and one can only wonder why IBM has not offered it yet. The PC would be more technically significant if the chip was supplied by IBM.

Overall, the system board represents a straightforward, conservative design. IBM took no chances, opting instead for reliability and economy. Not technically advanced, but competent and business-like. That's the good news, and pleasing it is. The bad news is one glaring omission: the system board does not contain a serial port.

The PC would be a better-equipped machine if the parallel printer port and one asynchronous port were an integral part of the system board. The cost would have been minimal, far less an increment that the cost of the plug-in adapters, and no slots would have been wasted. This writer has seen very few machines without both ports; those having neither are rare birds indeed. The system board is not densely packed with circuitry so there is almost certainly room for both.

The lack of the serial port is a serious failing, and one that was partially corrected with the XT.

PERIPHERALS

We have discussed the display and printer already. Now we will turn our attention to the most important peripheral adapters provided by IBM.

OVERALL, THE SYSTEM BOARD REPRESENTS A STRAIGHTFORWARD, CONSERVATIVE DESIGN. IBM TOOK NO CHANCES, OPTING INSTEAD FOR RELIABILITY, ECONOMY.

THE DISKETTE ADAPTER

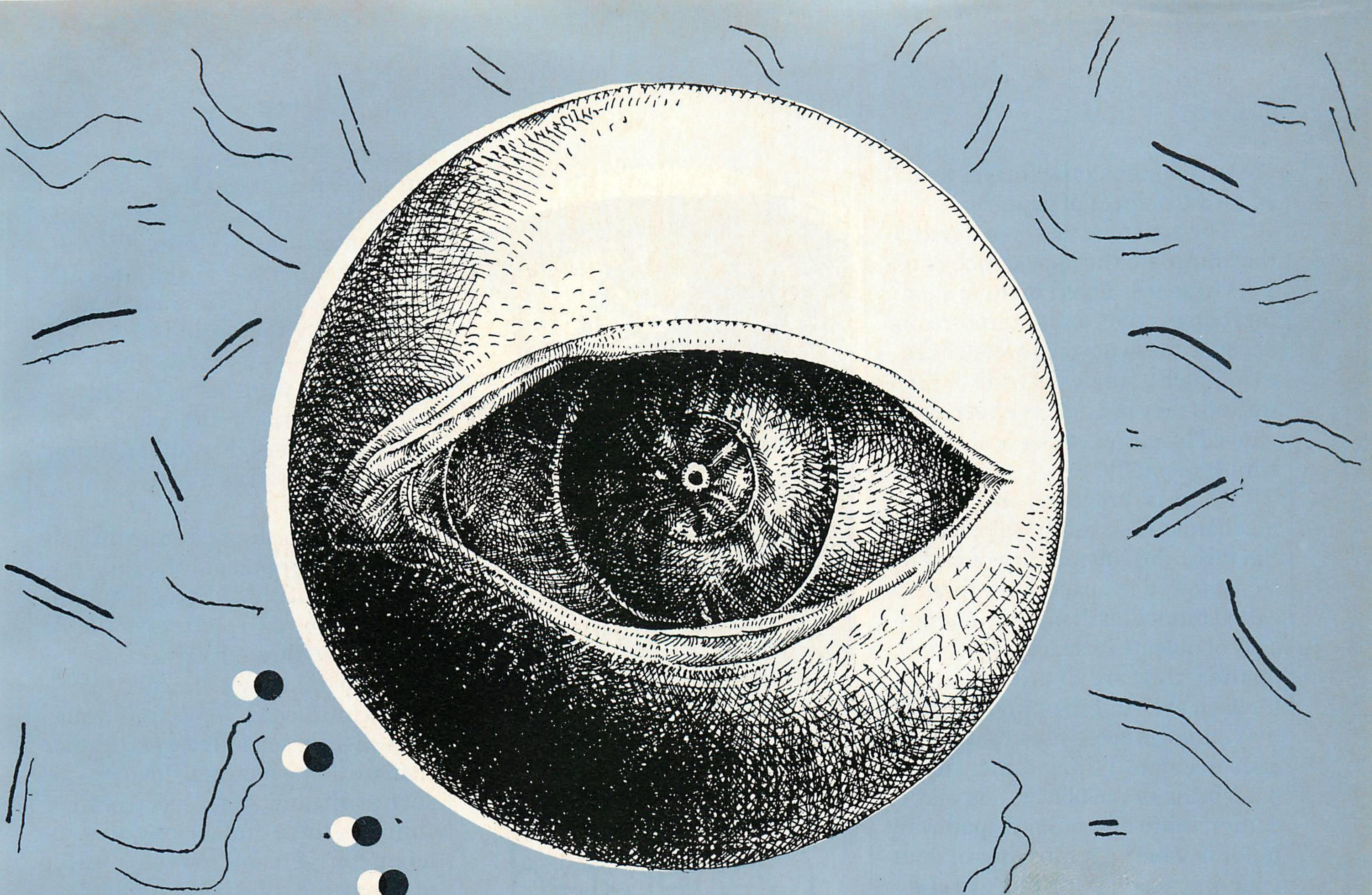
The IBM diskette adapter is a very powerful device, more so than IBM allows. It is based on the NEC 765 controller, and is capable of supporting both five and one-fourth-inch and eight-inch diskette drives. It is entirely driven under software control, and can thus be an effective device over a long period of time. The controller is so powerful that, with minimal effort, a systems programmer can build software to read disk formats from other computer systems. A program to convert a TRS-80 Model III diskette to IBM format is not difficult, although interpretation of the data is a necessary second step.

IBM has not used much of this power. So far, IBM has used only double-density diskette formats with single-sided or double-sided, eight- or nine-sector tracks. Formatted capacities have ranged from 160KB to 360KB. There is no IBM eight-inch offering, although other vendors have built such subsystems.

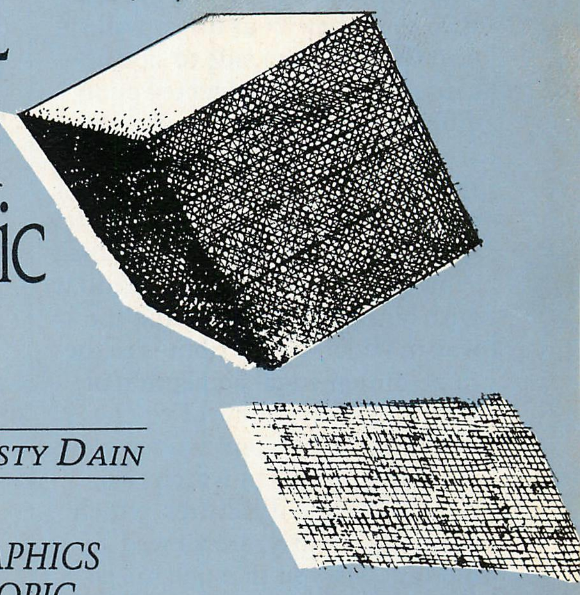
Worse, IBM started out with very high-priced, low-capacity drives. Even at the time the PC was announced, 160KB drives were considered small; companies routinely offered up to 500KB drives in small business systems. The so-called "quad-density" drives were just beginning to appear, with capacities of about one megabyte.

It is hard to find a reason why

(continued on page 169)

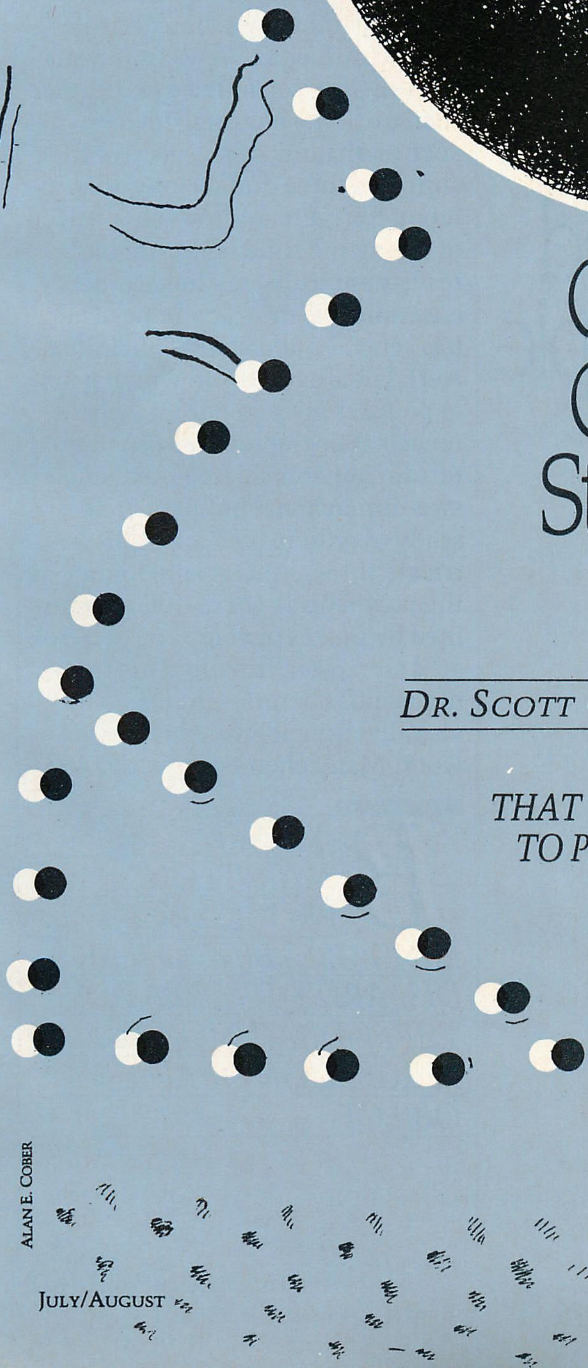


Computer-Generated Stereoscopic Images



DR. SCOTT CAMAZINE AND WESTY DAIN

BASIC PROGRAMS THAT UTILIZE SIMPLE GRAPHICS TO PRODUCE STEREOSCOPIC PAIRS OF IMAGES.



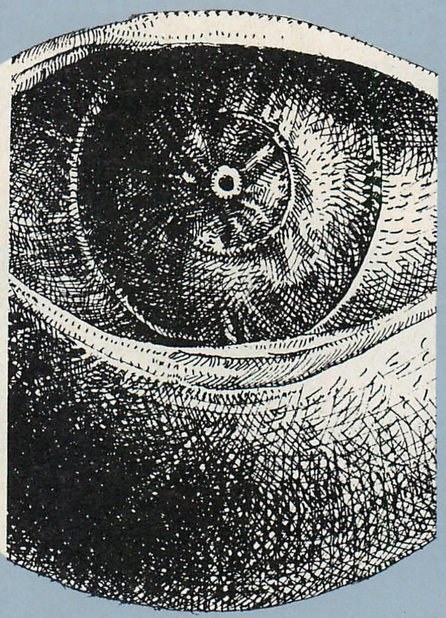
ALAN E. COBER

How is it that man is able to perceive in three dimensions when images received by the eye are projected onto a two-dimensional retina? Similarly why do we perceive certain illustrations as three-dimensional when we know that they

are two-dimensional images printed on a flat sheet of paper?

The artist uses a set of devices that simulate the appearance of objects in space. These include shading, perspective, and interposition. Because these devices are utilized to produce a single drawing or illustration, they are just as effective if viewed by either eye or both eyes simultaneously.

There is, however, another mechanism by which we perceive the three-dimensionality of real objects viewed in space, a mechanism called binocular disparity. The images of objects in space, projected on the retina, are slightly different for each eye, and the mind by some marvelous process uses that difference to create a three-dimensional perception of the object. It is easy to demonstrate binocular disparity by holding your finger in front of your nose and closing first one eye and then the other. Your finger will appear to jump from side to side because its image is projected upon different areas of each retina. We are all familiar with shading, perspective, and interposition as the pictorial cues that we see every day in paintings, photographs, and magazine pictures. We are less familiar with binocular disparity and the way in which it contributes to the three-dimensional perception of objects. Perhaps some of you have used the old-fashioned stereo viewer (stereopticons) in which two, two-dimensional pictures, which vary only slightly, are viewed simultaneously so that one image is projected on the retina of one eye and the other image is projected into the other eye. These pictures are produced in such a way that



Computer-Generated Stereoscopic Images

these are the images that each eye would see if it were to individually view an actual three-dimensional scene. In other words, the binocular disparity of the pictures duplicates the disparity that would be produced if the actual three-dimensional scene were being viewed by both eyes. The simultaneous viewing of the two slightly different images is perceived as three-dimensional.

The old-fashioned stereopticon pictures, so popular at the turn of the century, could be produced simply by taking two pictures of the same scene through cameras that were separated by a distance that would mimic the views from your own slightly separated eyes. Rather than utilizing pictorial devices such as shading or perspective to simulate three dimensions, the stereopticon recreates the actual effect of seeing the solid objects and the results are truly startling. Not only entertaining, this technique also has several important applications. Aerial photography, in which pairs of pictures are taken from a plane, reveals topographic features of the terrain not appreciated from single two-dimensional pictures. In the study of protein structures the intricate three-dimensional folding of the polypeptide chain can be examined by means of computer-generated stereoscopic pairs. This technique aids chemists in the visualization of how enzymes work. Many chemistry textbooks

BY SOME MARVELOUS PROCESS THE MIND USES BINOCULAR DISPARITY TO CREATE A THREE-DIMENSIONAL PERCEPTION OF AN OBJECT.

and scientific articles include stereo pairs of molecular structures, which help the reader understand the three-dimensional relationships of molecules.

Using the graphics capabilities of PC one can experiment with a variety of programs that produce pairs of stereoscopic images. The programs are based upon two equations, which convert any set of points in space with coordinates (X,Y,Z) to two sets of points projected on a plane. The following equations produce the left-hand image:

$$X1 = [(X-E) * ZO/Z + E] * F$$
$$Y1 = [\, Y * ZO/Z \,] * F$$

The equations for the right-hand image are similar:

$$X2 = [(X+E) * ZO/Z - E] * F$$
$$Y2 = [\, Y * ZO/Z \,] * F$$

X1 and Y1 are the corresponding coordinates of the point (X,Y,Z) projected onto the plane for the left eye to view.

X2 and Y2 are the coordinates of the point (X,Y,Z) projected onto the plane for the right eye to view.

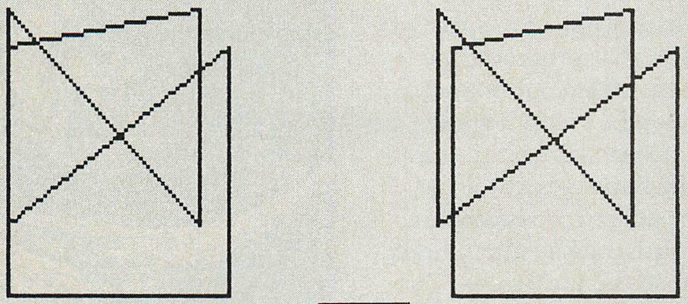
E is the distance in inches from the center of your face to each eye (thus 2 * E is the interocular distance).

ZO is the distance from your eyes to the plane upon which we project the images (6 inches is a good viewing distance).

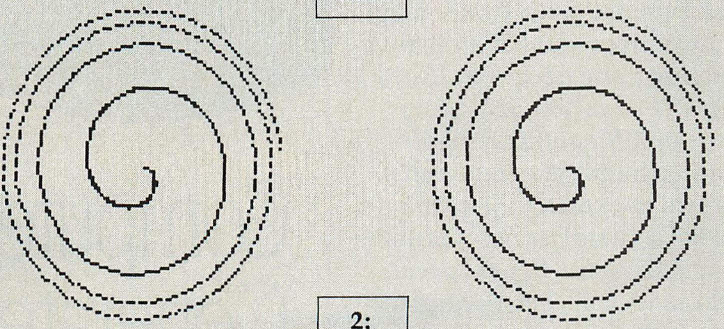
Z is the distance from your eyes to the object in space (30 inches is good).

F is a scaling factor to enlarge the image to the proper size.

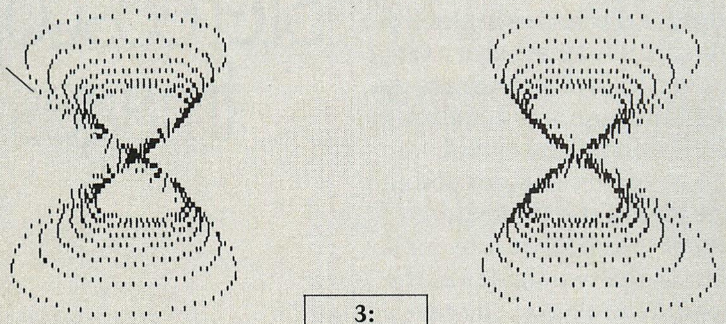
An excellent discussion of these



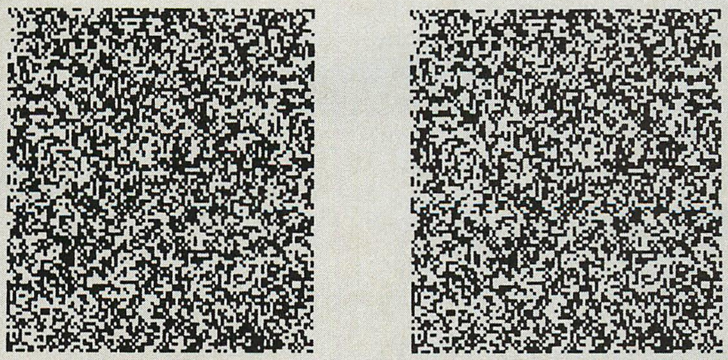
1: Cube



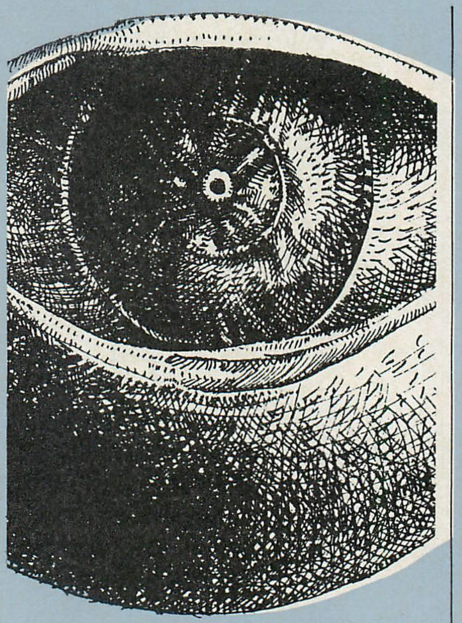
2: Helix



3: Lissajou



4: Random dot



Computer-Generated Stereoscopic Images

equations is William T. Powers' article "The XYZ Phenomenon" (*Byte*, October, 1979).

If you have the X, Y and Z coordinates of any object in space or the equation that generates the three-dimensional coordinates of a curve or surface, you can apply these equations to generate stereo pairs. In the listings that follow, you will be able to produce stereo pairs that illustrate a cube, a helix, and various lissajous figures. The simplest example is that of a cube. The coordinates of the eight corners of a cube are given in the data statements (lines 580-650 in listing 1). Applying these equations (lines 390-400 and lines 500-510) generates pairs of X,Y coordinates for each corner coordinate. Lines are then drawn to connect the corners to produce a "wire figure." Viewed stereoscopically the figure appears three-dimensional. The listings for the helix (listing 2) and the lissajous figures (listing 3) are produced in a similar manner except that the equations for the curves in three dimensions are used instead of a set of points given in data statements. As you might imagine, any equation in three dimensions can be used.

In most of these figures you can get some idea of the three-dimensionality of the object just by looking at one of the two figures in the stereo pair. However, in the randomdot program (listing 4) a square of random dots is produced that does not reveal the slightest hint of the three-dimensional nature of the stereo pair. These figures were devised by Bela Julesz, a scientist at Bell Telephone Laboratories. He utilized these pictures as an ingenious means of producing stereo pairs that eliminate all pictorial cues. He generated a random dot pattern, which incorporated a precise kind of binocular disparity. When viewed stereoscopically, the figure shows a small square composed of random dots hovering above a larger random dot square. The listing shows how the effect is produced. Two identical large squares of random dots are drawn on the screen. Then a smaller square is erased from within each large square. However, the smaller squares are offset slightly towards the center of the screen. These smaller squares are then filled in with identical random dot patterns. The small squares "disappear" against the background of random dots, but the binocular disparity created by offsetting the two squares is sufficient to make them "reappear," hovering above the larger squares when viewed stereoscopically. Similarly, the smaller squares can be made to appear recessed by displacing them outwards with reference to the larger square. This can be done in the program by changing the sign of the variable S.

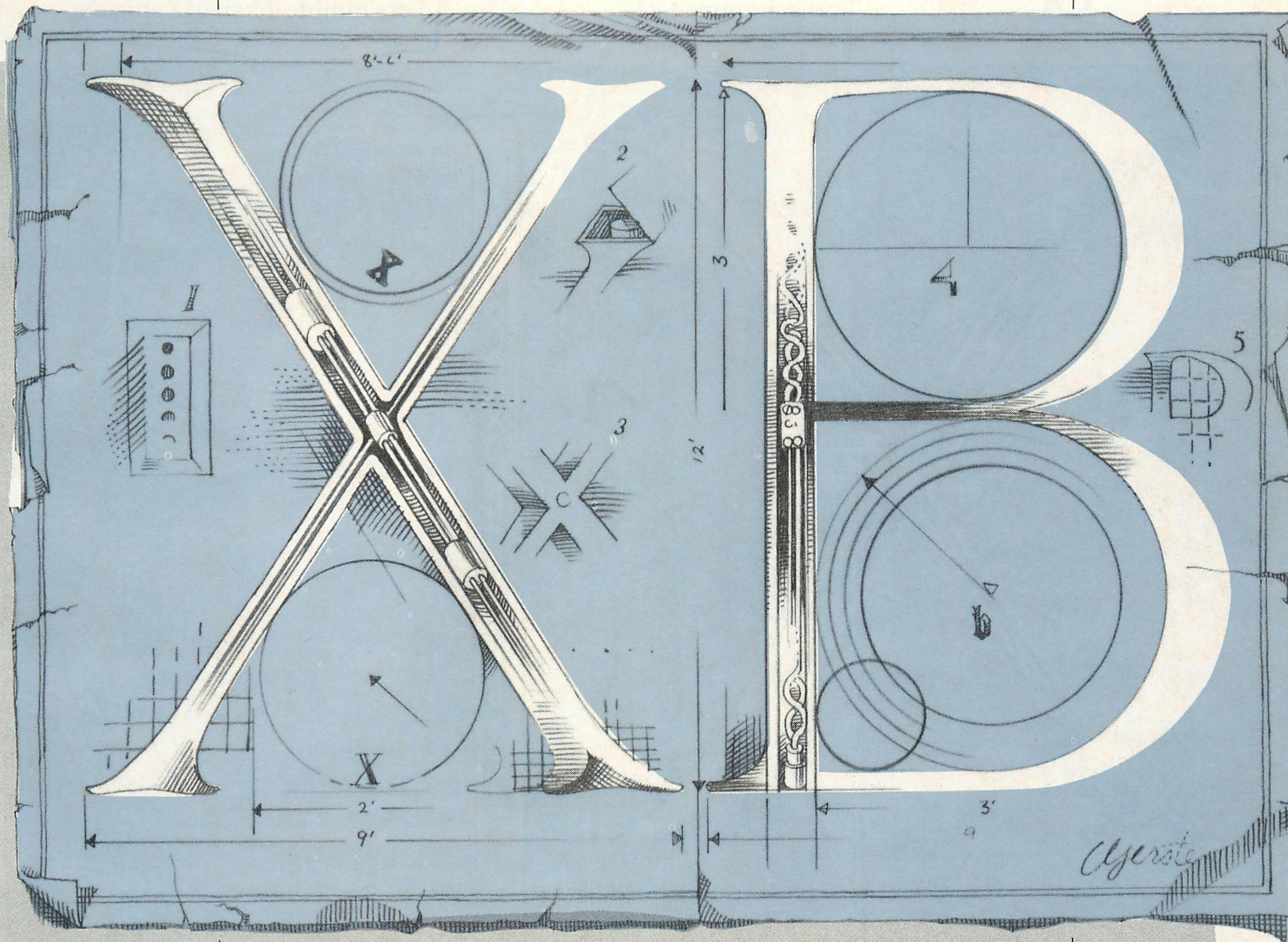
These studies by Julesz were a brilliant examination of how the mind creates three-dimensional images. Details of his experiments along with a number of unusual stereo pairs can be found in *Scientific American*, February, 1965. A great deal of work must still be done before we truly understand how the brain processes visual information. Meanwhile, however, there is an endless world of natural beauty, art, and optical illusions to delight our eyes and mind. □

Listings for this article are to be found on pages 191, 192 and 194.

Scott Camazine is a research associate in the Department of Neurobiology and Behavior at Cornell University. He is also a practicing physician.
Westy Dain is a research support specialist in The Department of Geological Sciences at Cornell.

SHOULD YOU BUY AN IBM SOFTWARE PACKAGE? IF THE ANSWER TURNS ON LEGAL REMEDIES, PROBABLY NOT.

The Anatomy & Construction of



Gerry Gersten

Richard M. Foard

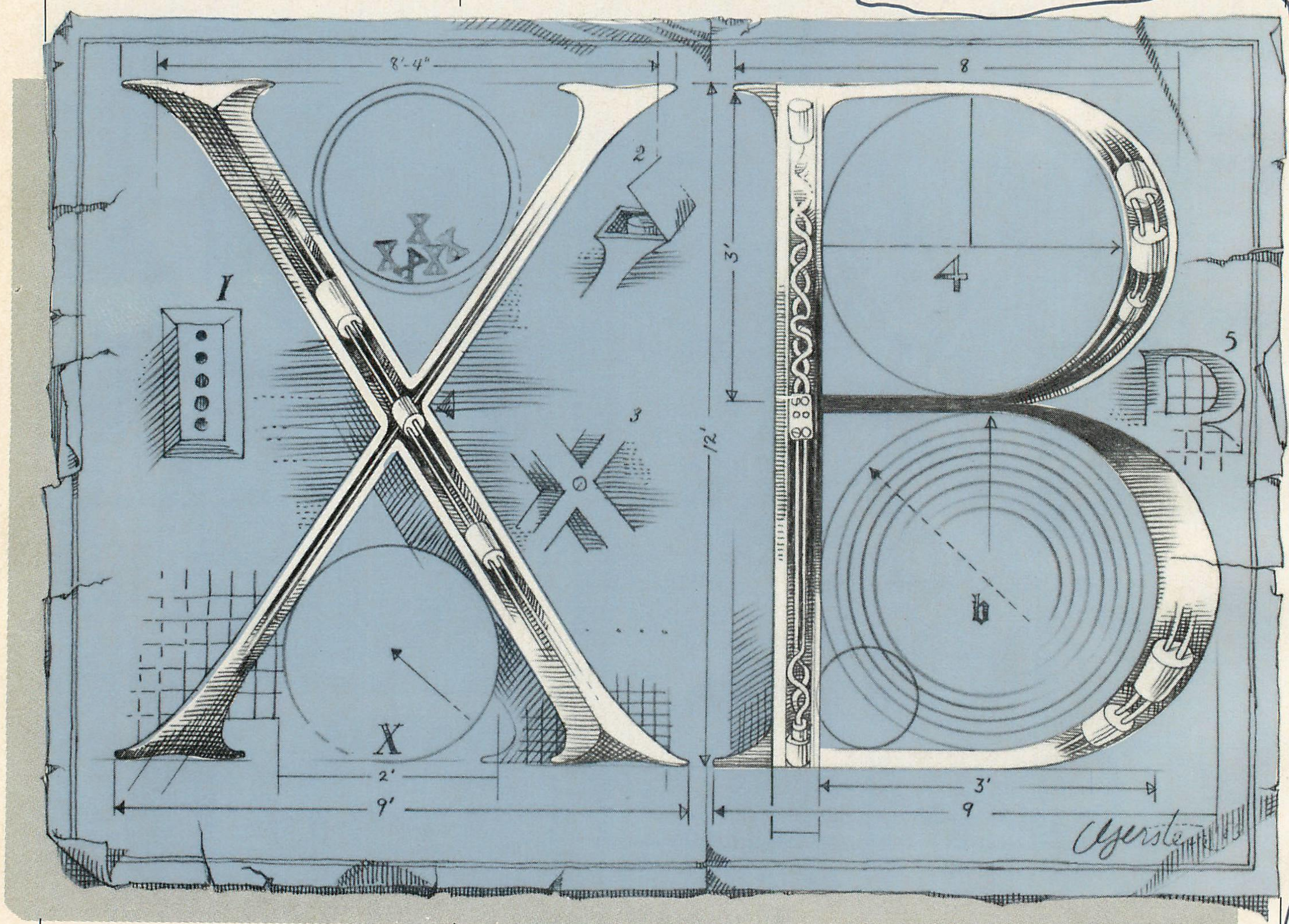
AN EXPERT BUILDS A SIMPLE BUT ELEGANT EXTENSION TO BASIC.

I hate BASIC. With all due respect for its inventors' vision and ingenuity, I must say that it is a real jalopy of a programming language when applied to any problem requiring more than a screenful of solution.

History, however, has firmly entrenched BASIC in the personal computing marketplace and, more specifically, in my IBM Personal Computer. When I bought my machine, my budget left me a little

The Anatomy & Construction of

software-poor, and I had a limited choice of programming languages: Cassette BASIC, Disk BASIC, or Advanced BASIC. The first program I wrote on the IBM played a little tune on its speaker. It was in BASIC. The second program, XB, replaced BASIC in my repertoire of programming tools.



XB and a Word about Precompilers

XB (Experimental BASIC) is a simple language that looks a lot like BASIC but without some of its deficiencies. It is implemented as a precompiler that translates XB programs into BASIC. Pre-compilers are far from being a new idea. Hundreds are available commercially, especially in FORTRAN and COBOL circles. Their abundance is not surprising because they make good sense. They're relatively easy to design because they don't implement whole new languages; they simply extend existing ones in areas where they fall short. They're quick to implement because most of the hard work of compilation — parsing every minute detail of a program — and the *very* hard work — generating good object code — can be passed along to the target language compiler. They can even make good business sense because they allow programmers to work in a language tailored to their particular needs and preferences without divorcing themselves from the benefits of having their end products in a

standard, widely supported language.

The remainder of this article describes XB's syntax and its rationale, describes the implementation approach, sketches the structural components of the compiler, and attempts some evenhanded evaluation of its effectiveness as a programming tool. It is intended to provide insight into how easily precompilers can be constructed as well as to explain the XB language experiment itself.

The Trouble with BASIC

BASIC does little to help programmers manage complexity. Although its GOSUB statement allows the use of subroutines, BASIC subroutines can't be passed explicit parameters and must be referred to by line numbers. Worse, BASIC's primitive control structures require programmers to use test-and-jump control logic; in this respect, programming in BASIC is like programming in assembly code. In fact, it's a little *worse* than programming in assembly code because BASIC's subroutine names, unlike those in assembly programs, are a bunch of meaningless numbers that become moving targets when program statements are "renumbered." Out of these two shortcomings grew XB's design goals: banishing line numbers and providing a more modern, rational set of control structures.

XB'S DESIGN GOALS ARE TO BANISH LINE NUMBERS AND PROVIDE A MORE MODERN, RATIONAL SET OF CONTROL STRUCTURES.

BASIC requires line numbers so that statements may be referenced as the destinations of GOSUB's and GOTO's. In place of line numbers, XB provides a facility for attaching mnemonic names to subroutines or to statements. XB's control structures allow programs to be written in a structured way so that few statements must be explicitly labeled anyway. It's common for structured programs, even very large ones, to contain no statement labels whatsoever.

XB Syntax — Not Quite a Superset of BASIC

Almost any legal BASIC statement is a legal XB statement. The exceptions to this rule are a result of XB's dependence on reserved words. XB reserves the words: "Procedure", "Endproc", "Do", "If", "Else", "Elseif", "Endif", "Repeat", "While", "Until", and "Endrep". "If" and "While" are significant members of this list because they are also BASIC reserved words. XB's "if statement" and "while loop" constructs are syntactically different from BASIC's, and consequently a BASIC IF statement appearing in an XB program will be interpreted by the compiler as an erroneous XB IF statement. XB "steals," in effect, these keywords from BASIC.

Unlike BASIC, which allows multiple statements to appear on a single line, XB requires that any statement beginning with an XB keyword appear first in a line of program text. This requirement was not motivated so much by pure language design considerations as it was by program design; it is an expedient that allowed some shortcuts in the implementation of the compiler. Pure BASIC statements may be grouped many on a line in XB programs, just as they may be in BASIC programs.

Procedure Declarations and Calls

Unlike BASIC, in which any statement may be GOSUB'ed to, XB requires the explicit declaration of procedures using the bracketing keywords "Procedure" and "Endproc" (XB keywords may appear in any mixture of upper and lower case letters):

```
Procedure ⟨procedurename⟩
    .
    .
  ⟨XB statements⟩
    .
    .
Endproc
```

Procedures are called using the XB "Do" statement:

```
Do ⟨procedurename⟩
```

THE FLOATING EXIT TEST IS VALUABLE BECAUSE IT ENABLES PROGRAMMERS TO PROGRAM IN A STRUCTURED WAY WITHOUT HAVING TO DUPLICATE CODE.

Labels

Any line in an XB program may be preceded by labels of the form:

```
@⟨labelname⟩:
```

The program line following a label may be referenced from anywhere in the program text as "@⟨labelname⟩".

If Statements

XB's "If" statement implements the classical "if-then-else" construct with one twist. Its basic syntax is:

```
If ⟨BASIC logical expression⟩
.
XB statements executed if
the condition is true
.
Else
.
XB statements executed if
the condition is false
.
Endif
```

THE OBVIOUS DRAWBACK OF XB IS THAT IT REMOVES PROGRAMMERS FROM THE COMFORTABLE, HIGHLY INTERACTIVE BASIC PROGRAM DEVELOPMENT ENVIRONMENT.

The "Else" clause may be omitted; the "Endif" must end every "If" statement.

XB's additional twist to the time-honored "If" statement is the "Elseif" clause, which allows the programmer to successively test a number of conditions in a single If statement. The XB "If" statement, in its general form, looks like this:

```
If ⟨BASIC logical expression⟩
.
XB statements
.
Elseif ⟨BASIC logical
        expression⟩
.
XB statements
.
Elseif ⟨BASIC logical
        expression⟩
.
.
.
Else
.
XB statements
.
Endif
```

The Elseif and Else clauses are optional.

Chains of "Elseif" clauses allow programmers to test a number of conditions of equal logical weight without being forced to artificially subordinate later tests in a set of nested, traditional "If" statements, as in:

```
If ⟨condition⟩
  statements
Else
  If ⟨condition⟩
    statements
  Else
    If ⟨condition⟩
      statements
    Else
      statements
    Endif
  Endif
Endif
```

Repeat Loops

XB's conditional loop construct, like its "If" statement, implements the traditional "while loop", with one wrinkle: the exit test is allowed to appear anywhere inside the body of the loop. In general, the conditional loop has the syntax:

```
Repeat
.
XB statements
.
Until (or While) ⟨BASIC
          logical
          expression⟩
.
XB statements
.
Endrep
```

The "floating" exit test is valuable because it enables programmers to program in a structured way without having to duplicate code in situations like this one:

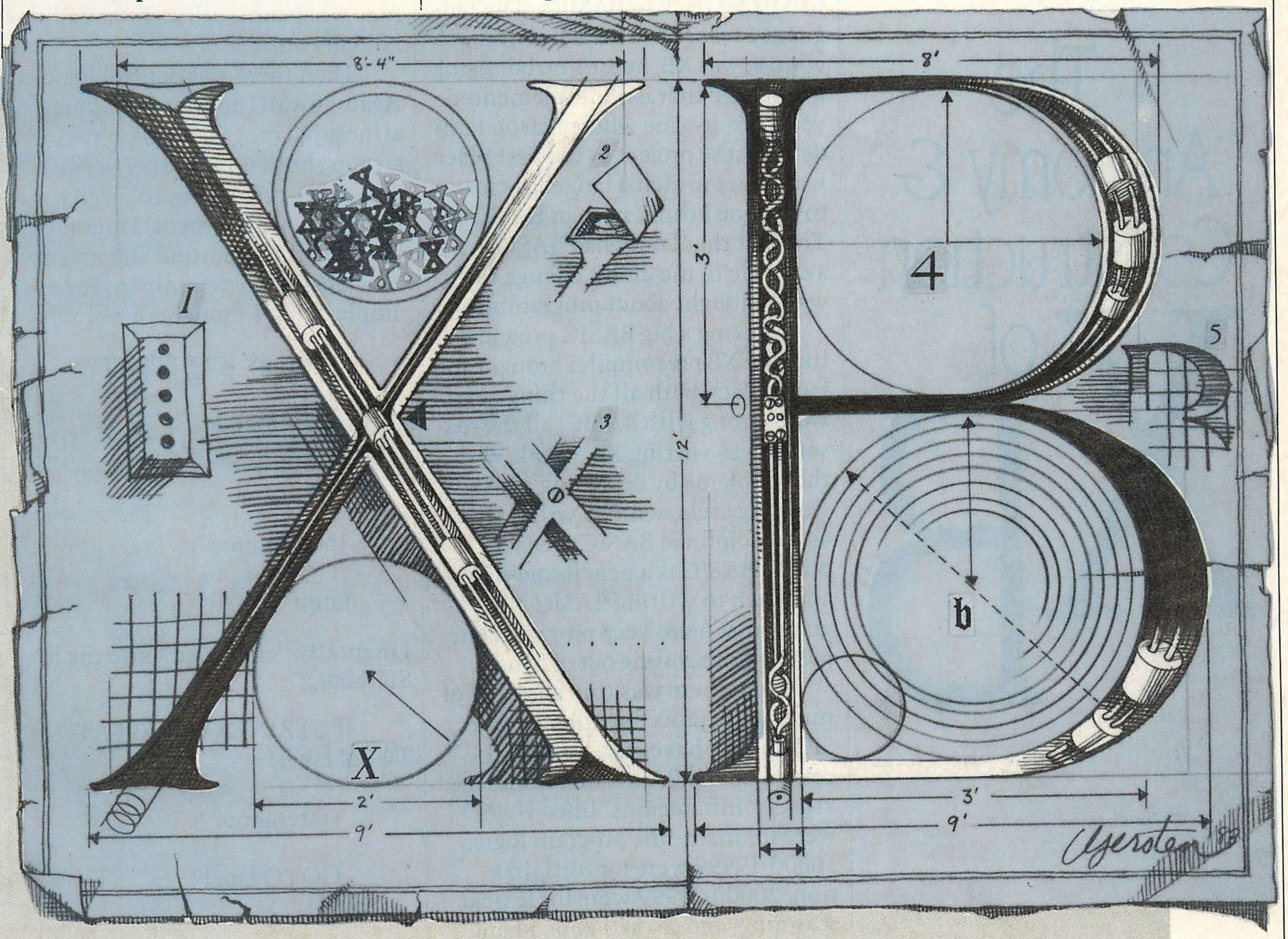
```
Repeat
  read line from file
Until end-of-file
  process line
Endrep
```

which, with the more traditional form of the while loop, would look like:

```
read line from file
While not end-of-file
  process line
  read line from file
Endwhile
```

XB's syntax also allows convenient expression of conventional

The Anatomy & Construction of



loops by permitting the exit tests to accompany the Repeat keyword:

Repeat While ⟨BASIC logical expression⟩
.
XB statements
.
Endrep

or, Repeat Until ⟨BASIC logical expression⟩
.
XB statements
.
Endrep

Other precompilers (and other languages) have allowed floating exit tests by providing an "exit" statement which, when executed inside a loop, causes transfer of control to the statement immediately following the end of its immediately enclosing loop. The explicit keywords "While" and "Until" were selected for XB because they make for a more direct and easily readable specification of loop con-

THE KEYWORDS "WHILE" AND "UNTIL" WERE SELECTED BECAUSE THEY MAKE A MORE DIRECT AND EASILY READABLE SPECIFICATION OF LOOP CONTROL AND TERMINATION CONDITIONS.

The Anatomy & Construction of XB

trol and termination conditions. Exit statements, I've found, tend to get buried deep inside embedded If statements and make program logic harder to follow.

To Implement! — "Disciplined BASIC"

In planning XB's implementation, I had to get back to BASICs. The language I *wanted* to implement in, of course, was XB, but it's no fair using a language that isn't implemented yet. Or is it? The whole reason I undertook the project in the first place was to get myself a language closer to the one I think in than BASIC is. The fact that I only had BASIC available to me didn't change the way I thought about programming.

Writing a big BASIC program like the XB precompiler brought me face to face with all the things that were wrong with BASIC, all the reasons I was writing XB. I dealt with the problems by designing a BASIC working style, which I will refer to as "Disciplined BASIC." Disciplined BASIC is a pencil-and-paper approach to writing BASIC programs that helps keep program complexity from getting out of hand.

First, there was this business of mnemonic procedure names. BASIC doesn't have any, but *I* do. I carved up the BASIC line number "space" into regions: lines 1-9999 were for main-line program logic, 10000-19999 were for initialization, 20000-29999 were for lexical scanning, and so on. I kept a handwritten table of my subroutine names and their corresponding BASIC line numbers. That decision provided a rough guide for where to put subroutines (how to "name" them) as I developed them. Then I imposed a pencil-and-paper rule on myself: each time I wrote a procedure call (GOSUB statement), I accompanied it with a comment giving the name of the procedure being called. What BASIC didn't allow me to do in program text to recognize what subroutines I was calling, I did in comments.

Then there was control logic. Again, BASIC doesn't have many structured programming constructs, but *I* do. Another pencil-and-paper rule was born. Each time I wrote an If statement, I mentally inverted the condition and invented a label name to jump to. For example, what I thought of as:

```
    If string$ = "REPEAT"
      .
      statements
      .
    Else
      .
      statements
      .
    Endif
```

I mentally "compiled" into the BASIC code:

```
    IF STRING$ <> "REPEAT"
THEN label1
      .
      statements
      .
      GOTO label2
   label1:
      .
      statements
      .
   label2:
      .
      .
```

BASIC, of course, didn't let me get away with labeling lines "label1" and "label2". When I arrived at a statement which I'd labeled that way, I noted the BASIC line number on which it fell and went back with my eraser and changed all the occurrences of "label1" to what the real line number was (Disciplined BASIC doesn't work well with a pen). I used similar mental transformations for conditional loop structures.

Armed with my pencil, eraser, and table of procedure names, I set to work writing XB in Disciplined BASIC.

XB Components

The basic structural components of the compiler were dictated by the requirements of its task. The XB program would have to be read from a disk file in units which made the compiler's work convenient (lexical scanning). XB would have to recognize and "understand" the program's intended structure (parsing). XB would have to maintain a table of procedure name/line number correspondence much as I did on paper in Disciplined BASIC (symbol table management). Finally, XB had to generate BASIC statements which accomplished the intent of the XB programmer (semantic routines and code generation).

ARMED WITH MY PENCIL, ERASER, AND TABLE OF PROCEDURE NAMES, I SET TO WORK WRITING XB IN DISCIPLINED BASIC.

I made a philosophical decision at the outset of my program design effort to put correctness over performance. That is, I allowed myself to throw caution to the winds as far as worrying about how fast the XB compiler would run was concerned and to concentrate instead on writing a simple, easy-to-understand program which I firmly believed did what it was intended to do. This is an approach I'd recommend to any programmer approaching a problem for the first time, even though it doesn't tend to produce commercially viable results all the time. Put simply, I chose to make it *right* first, then make it *fast* later.

Scanning

The XB compiler reads the source program line by line, and processes each line by calling the scanner to break it into pieces ("tokens"), which are easily dealt with by higher-level routines. Because XB is not a full-blown compiler, the scanner needs only to make a rough analysis of the program text, classing each phrase of source code as a quoted string, name, user label, end-of-line, or "other". A quoted string is any text sequence enclosed in double quotes. A "name" is a legal BASIC variable name. User labels are XB line labels of the form "@(labelname)". End-of-line is the scanner's indication to calling routines that the current line of program text is exhausted, and characters encountered by the scanner which are not part of one of the other four scanner elements are classed "other."

Parsing

XB's parsing, like its scanning, requires far less work than a full language compiler's does because XB syntax was designed to make the job very easy. First, the precompiler doesn't need to understand the structure of pure BASIC statements; these are simply passed along in the BASIC program output. It must recognize only those statements that contain XB keywords, a task simplified by the requirement that they appear first in a line of program text.

Parsing proceeds as follows: given a newly read line of program text, the routine "proc line" discards any numeric tokens (this is where the precompiler removes BASIC line numbers present if the XB program was prepared using the BASIC screen editor). Next, it notes the presence of XB line labels, if any. Then, if the next token type is "name", it inspects the token to determine if it is an XB keyword. If it isn't, the parser's job is done for this line; this token and the rest of the line is assumed to be pure BASIC and is passed through to the BASIC output program. If it *is* an XB keyword, "proc line" dispatches to one of a number of semantic routines which, with the help of symbol table and code generation routines, translates the XB construct into equivalent BASIC code (these routines do a little more parsing).

I MADE A PHILOSOPHICAL DECISION AT THE OUTSET OF MY PROGRAM DESIGN EFFORT TO PUT CORRECTNESS OVER PERFORMANCE.

The Anatomy & Construction of XB

Support for the Semantic Routines

Because the XB precompiler removes the responsibility of assigning BASIC line numbers to program statements from the XB programmer, *it* must number the BASIC statements it outputs so that BASIC can make sense out of them. This function is performed automatically by the code generator, which numbers lines in increments of ten. XB must also provide line numbers in the BASIC output program where the XB programmer has *referenced* program locations by name, as in the XB procedure call statement "Do readline". To meet this requirement, the precompiler must maintain a symbol table in which it records the correspondence between XB names and line numbers in the generated BASIC program.

There are two kinds of names which the XB programmer defines and references explicitly which must be recorded in the symbol table: labels and procedure names. There is a third kind of name which the XB programmer defines and references *implicitly,* whenever he writes an "If" or "Repeat" statement. This is a "generated" label, one which is used by the precompiler to generate the BASIC test-and-jump logic necessary to accomplish the effect of an XB If or Repeat statement. For example, where the XB programmer writes:

```
If a = b
  statement
Endif
```

the XB precompiler generates:

```
If not (a = b) then goto label
statement
label:
```

"label" is invented by the precompiler without effort by or knowledge of the XB programmer, and is stored away in the symbol table just as an explicitly defined procedure name or label would be stored.

Some references to both explicitly and implicitly defined labels pose an obvious problem for the precompiler: they refer to names for which the compiler has not yet encountered definitions because they reference "forward" in the program. One natural way for a compiler to handle this problem is exactly like the Disciplined BASIC programmer's solution: wait until the label is defined, then go back and insert the correct line number in every previous statement which referenced it. Though there is nothing wrong with this approach, sometimes referred to as "backpatching," the XB precompiler uses an even simpler expedient to deal with the problem which avoids backpatching or additional passes over the source or object programs.

Each time the precompiler encounters a forward reference to a label, it inserts the label name in its symbol table and stores as its line number value a unique, very large BASIC line number. Then, when it has reached the end of the XB program and learned the "real" line number values of all the labels in the program, it generates a series of BASIC statements with the very large line numbers it assigned artificially, each of which reads simply: "GOTO ⟨corresponding 'real'

THE XB USES A SIMPLE EXPEDIENT TO "BACKPATCHING," OR ADDITIONAL PASSES OVER THE SOURCE OR OBJECT PROGRAMS.

line number⟩". Consequently the end of a BASIC program generated by XB contains a series of high-numbered GOTO statements which constitute a "jump vector" for all the forward-referenced labels in the program. For example, the XB-compiled version of:

```
Do initialize
If failure = true
  stop
Endif
Print "Successful."
Procedure initialize
open "infile" for input as 1
Endproc
```

compiles as:

```
10 GOSUB 65529
20 IF NOT (FAILURE = TRUE)
THEN 65528
30 STOP
40 PRINT "Successful."
50 '----INITIALIZE
60 OPEN "infile" FOR
   INPUT AS 1
70 RETURN
65528 GOTO 40
65529 GOTO 50
```

There are two other underlying facilities required to make the semantic routines' jobs relatively simple. One is a set of output routines which number, compose, and write the lines of generated basic code. "Put" appends a string to the developing line of generated BASIC. "Putline" writes the line composed by calls to "put" to the output file, then prepares the next output line by starting it with the next BASIC line number. "Copy to eol" copies from the input line of XB to the developing output line of BASIC up to, but not including the end-of-line marker itself. Because much XB source code is, in fact, already legal BASIC, "copy to eol" is used frequently by the semantic routines. "Copy to eol" also watches for XB label references as it copies tokens from XB to BASIC, and replaces user label references with corresponding BASIC line numbers.

The other facility is a pair of label stack maintenance routines named "pushlab" and "poplab", which do what their names suggest. A last-in first-out stack data structure is used to keep track of XB-generated labels as part of processing (possibly nested) XB loops and "If" constructs.

Semantic Routines

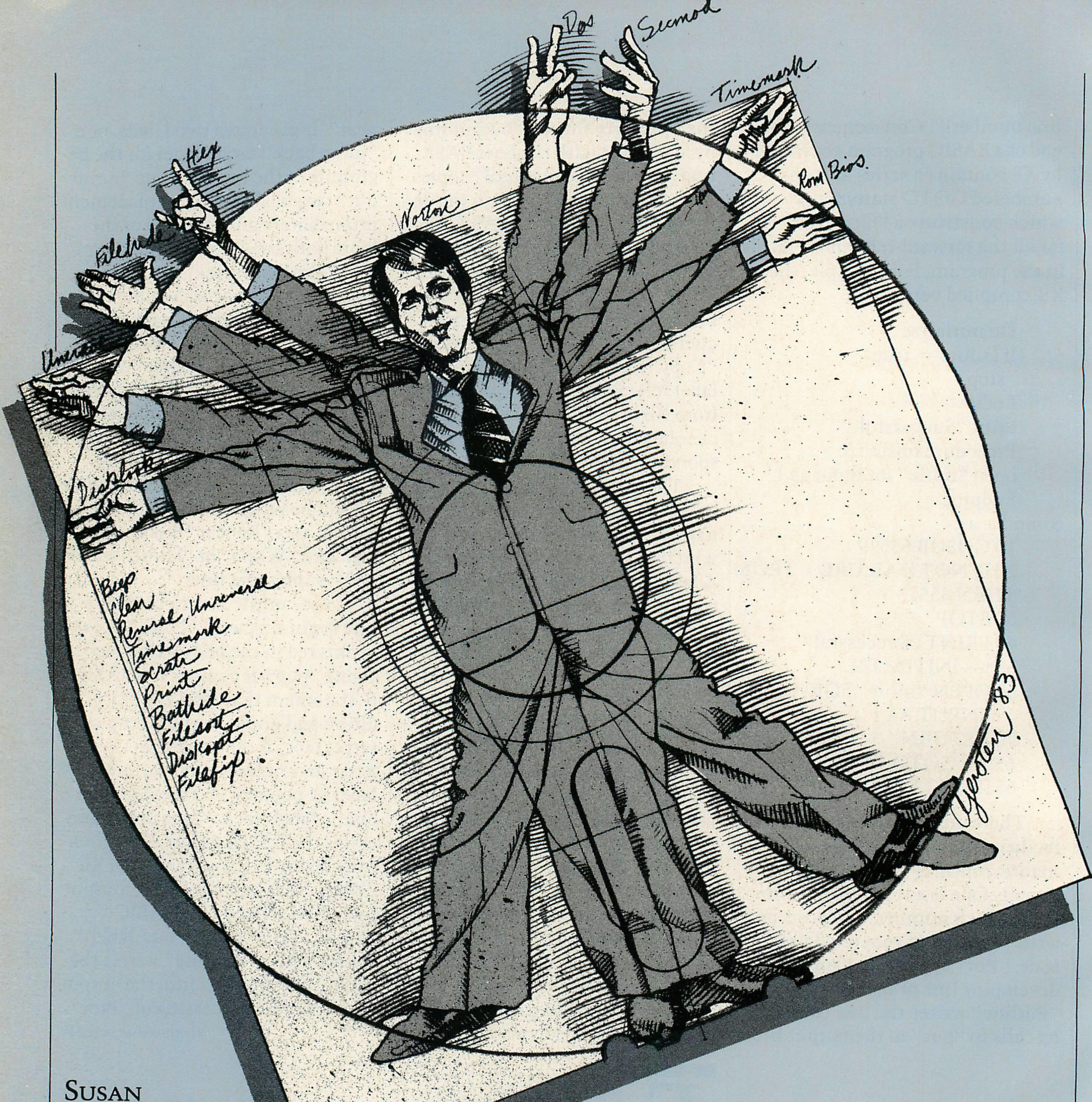
Given the underlying facilities of the symbol table manager, stack maintenance routines, and code generation primitives, constructing the semantic routines was relatively simple. The processing of a Repeat loop, for example, is accomplished by three routines, each of which is less than 15 lines of Disciplined BASIC.

The routine "proc repeat" is called to process program lines beginning with the keyword "Repeat". It generates two labels, one "jump back" target label for the beginning of the loop and one "jump out" target label for later placement immediately after the end of the loop. Both labels are recorded on top of the label stack; the "jump out" label must be accessible for processing exit test statements and the "jump back" label is required for processing the "Endrep" statement ending the loop. The "jump back" label is immediately placed, since the body of the loop is introduced by the "Repeat" keyword. The routine then scans again in the XB source program line to determine if this "Repeat" is accompanied by a "While" or "Until" condition on the same line.

"Proc until" is called when a line beginning with "Until" is encountered in the body of the loop. Using "put", it composes a BASIC IF statement that tests the exit condition and jumps to the "jump out" target label if the condition is true. After determining the "jump out" label by popping and re-pushing it on the label stack, "proc until" generates the BASIC phrase "IF", then calls "copy to eol" to copy the XB "Until" test into the BASIC output line, then appends the BASIC phrase "THEN ⟨'jump out' label⟩". A final call to "putline" writes the BASIC IF statement into the output program. The processing of "Proc

(continued on page 159)

EXPLICIT DECLARATION OF PROCEDURES IS REQUIRED BY XB, USING THE BRACKETING KEYWORDS "PROCEDURE" AND "ENDPROC."



Susan Glinert-Cole

The NORTON

Gerry Gersten

Software Review:

THE 14 ADJUNCT PROGRAMS IN THIS PACKAGE FOR THE IBM PC DOS HAVE EXCELLENT HUMAN ENGINEERING AND NO UNEXPECTED OR UNPLEASANT SURPRISES.

UTILITIES

The Norton Utilities are a set of 14 programs designed to be a powerful adjunct to the IBM PC-DOS. They range in complexity from simple to intricate and sophisticated functions of use to the advanced programmer. Some utilities permit minute exploration and manipulation of disk files; other programs provide DOS with convenient functions usually only accessible from IBM Basic. Minimum system configuration is one disk drive and 64K of memory, although a few of the utilities, which were not specified in the documentation, will run in a 48K system. The documentation itself is exceptionally well organized, informative, and clearly written. It follows the DOS graphic format and is designed to be inserted into the DOS manual. Peter Norton has that rare talent for explaining complex ideas in a cogent and comprehensible style, without being overly wordy or technical. The manual is educational in itself, and in conjunction with the utilities, provides an excellent educational tool for some of the advanced concepts of disk organization. Version 1.15 is compatible with JFORMAT, for those who have this utility available.

The set is provided on three single sided diskettes. This is particularly inconvenient in view of the fact that the DOS diskette must remain resident in one disk drive, since the utilities exit to the system. With care, all the programs can be packed onto two single or one double sided diskette, which considerably reduces the time spent swapping disks back and forth. Since some of the programs will be used only infrequently, the more frequently used functions may be copied to a disk with the DOS system on it. All of these programs are provided as external DOS commands and must therefore be accessible from a diskette when called from the operating system.

The major programs of the set, Disklook, Unerase, FileHide, and SecMod, as well as some of the minor ones, are all driven from very attractive and self-explanatory menus. All of these programs make effective use of the cursor and function keys and the menus are consistent from program to program. Function key 2 always causes information to be read from a diskette, F1 always returns to the main menu or, if pressed again, replaces the screen with the former display. F10 exits the program back to DOS. A few of the smaller programs, such as Beep and Clear, do not require menus and are simply invoked by

typing the command after the DOS prompt.

The Simple Utilities

These seven programs are most conveniently utilized from batch files.

BEEP - This command emits a loud piercing sound designed to call attention to a problem during batch processing.

CLEAR or CLS - This command clears and resets the screen. It is equivalent to the CLS command in Basic.

REVERSE - This changes the display to the reverse video mode. The screen remains in this format until reset by a CLS command or the SCATR command (see below). REVERSE would be better if it reversed the screen from one state to the other, as the word implies.

TIMEMARK - This utility displays the current date and time and will also calculate and display elapsed time (up to a 24 hour limit), using the Start and Stop operations.

PRINT - This utility is a simple formatting program, which transfers an ASCII file to a printer. A no-numbering option suppresses line numbers. PRINT inserts page breaks and prints the file name, current date and time at the top of each page.

BATHIDE - This function is designed as a batch processing utility which hides or unhides files. This is convenient when a program requires access to files which should normally be kept hidden, either to prevent accidental erasure or access by the wrong people.

The Intermediate Utilities

FILESORT - This very handy utility sorts file directories in one of four ways: alphabetically by file name, alphabetically by file name extension, by date and time of file creation, or by the size of the file. The program accepts one letter abbreviations for sort order. The complete file name is always used as the

The NORTON UTILITIES

The information may be shown on the right or left of the screen, and it is possible to suppress the display altogether if desired.

SCRATR - This command sets the screen to any desired display mode. Unlike the other programs in this set, this one is not very convenient to use. The screen attribute is set by passing either eight binary digits or two hex digits, thus requiring the user to calculate, using the IBM Technical Manual, the appropriate parameter. Hopefully an updated version would allow the input to follow the BASIC conventions for controlling the display.

secondary key, if required. Unfortunately, the copy in the set received for review did not work at all. The reviewer attempted numerous variations on the input parameters, with no success, and time was too short to obtain a working version.

DISKOPT - Designed to be used in conjunction with the COPY utility in DOS, this utility rearranges the directory entries on a disk into an order which has been designed to optimize access time. When this command is invoked, the directory entries are reordered; copying the diskette places the files in the same order as the reorganized directory.

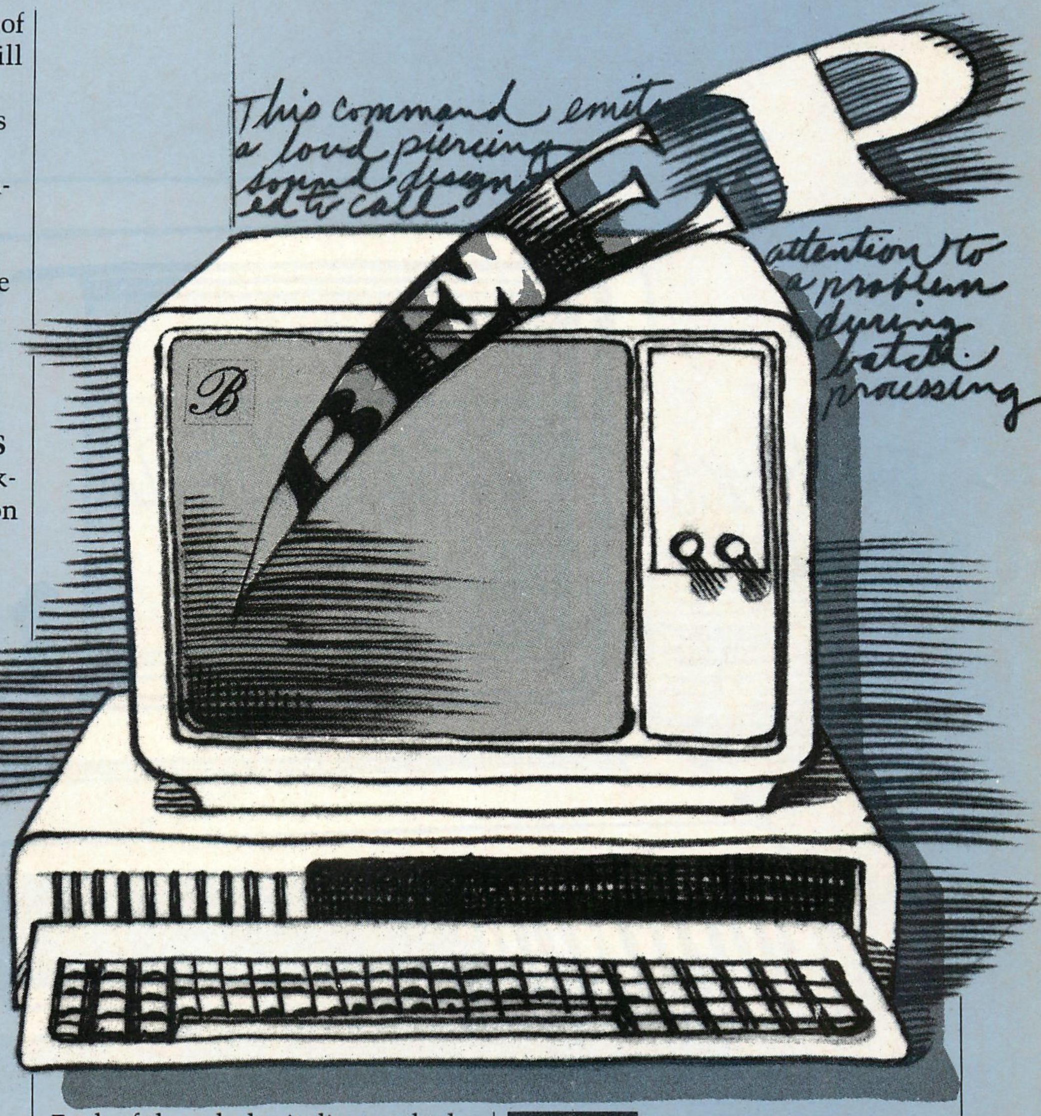
FILEFIX - It is the fervent hope of this reviewer that this program will never be needed. When called, it will check a file for damaged areas and attempt to recover those regions of the diskette which are undamaged. FILEFIX examines one sector of data at a time, removing any sectors found to be unreadable from the file's space allocation table. This allows the undamaged sections of the file to be copied.

The Advanced Utilities

The last four programs in this package presuppose some sophistication on the part of the user, although, with the exception of SECMOD, provide relatively straightforward functions. Since all of these programs deal in an intimate way with the organization of data files, we digress briefly to examine the manner in which information is stored on a diskette.

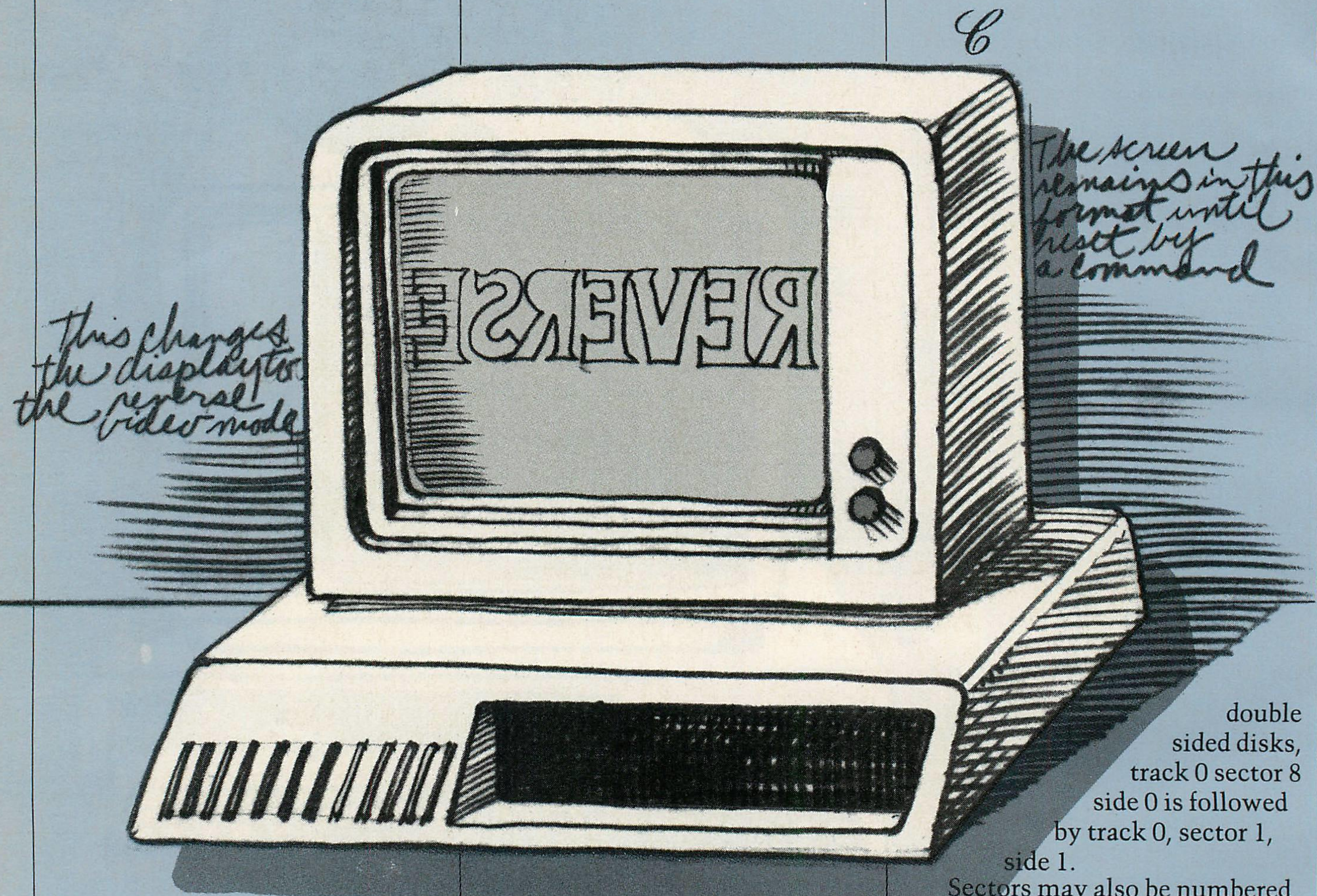
Unlike a phonograph record, which stores its information in one continuous spiral, data is recorded on a diskette in concentric circles called tracks. The IBM PC format specifies 40 of these tracks per disk, but other operating systems may support different numbers of tracks. Each track is divided, like a pie, into sectors; a diskette may be either hard or soft sectored. On hard sectored diskettes the number of sectors per track is strictly predetermined and may not be altered by software. If you look at a hard sectored disk, you will see ten or sixteen holes around the hub.

PETER NORTON HAS THAT RARE TALENT FOR EXPLAINING COMPLEX IDEAS IN A COGENT, COMPREHENSIBLE STYLE WITHOUT BEING OVERLY WORDY OR TECHNICAL.



Each of these holes indicates the location of one sector. The IBM PC uses soft sectored diskettes; only one index hole can be found at the hub, which delimits the beginning (or end) of the track. The sector size itself is flexible. Theoretically, a track can have only one sector, although this is not usually practical. The present format supported by DOS is eight sectors per track, each of which will hold 512 bytes of data. The ROM BIOS is capable of supporting other sector formats, which

THE SIMPLE UTILITIES ARE BEEP, CLEAR OR CLS, REVERSE, TIMEMARK, SCRATR, PRINT, AND BATHIDE.



allows the PC to run other operating systems which do not use the eight sector format.

When information is read from or written to disk, the operating system must have some way of keeping track of where the data has been stored and what areas of the disk are free to be written to. In fact, there are three primary ways used to map a diskette: track and sector number, absolute sector number and cluster number.

Track and sector number is used primarily by the ROM BIOS routines which do disk I/O. Tracks are numbered 0 to 39, beginning with the outermost track. If the disk is double sided, a further distinction is made between side 0 and side 1. Sectors in a track are numbered from 1 to 8. On a single sided disk, track 0, sector 8 is followed by track 1 sector 1. Double sided diskettes use the same track on the second side before moving to the next one, which doubles the amount of data accessible without moving the head and thus permits faster disk access. Therefore, on double sided disks, track 0 sector 8 side 0 is followed by track 0, sector 1, side 1.

Sectors may also be numbered according to an absolute sector number scheme. In this case, sectors are numbered continuously, on a single sided disk, from 0 to 319. Track 0, sector 1 is absolute sector number 0; track 1, sector 1 is absolute sector number 8 and so on, up to track 39, sector 8, which is absolute sector 319. If the disk is double

IF YOU HAVE JUST ACCIDENTLY ERASED A FILE AND HAVE DONE NO FURTHER WRITING TO THE DISK, IT IS NO PROBLEM TO RECOVER THE FILE IN ITS ENTIRETY WITH UNERASE.

sided, the absolute sector numbering continues on the other side with 320 (this would be track 0, sector 1, side 1) up to absolute sector 639. The DEBUG program in DOS uses absolute sector numbers when referring the disk information.

DOS has yet a third way of referring to disk organization, called cluster number. A cluster is merely a section of disk space which is allotted to a file. Single sided diskettes have one sector per cluster, and double sided disks have two. DOS uses a File Allocation Table (often referred to rather depressingly as the FAT) to keep track of which clusters are allocated to which files. Since files are not necessarily written to contiguous areas of the disk, the FAT not only contains the allocation information, but each entry in the table has a pointer to the next cluster of the file.

FILEHIDE WOULD BE USEFUL FOR ACCESSING SOFTWARE THAT HAS BEEN RECEIVED AS HIDDEN FILES AND FOR GIVING A NOMINAL AMOUNT OF PROTECTION TO YOUR OWN FILES.

The NORTON UTILITIES

Finally, there is the organizational section of PC DOS which is visible to the user: the diskette directory. The directory structure is initially built with the FORMAT program. For single sided disks, the directory may have 64 entries; dual sided diskettes may contain 112 entries. Each entry of the directory is 32 bytes long and contains all of the information pertaining to a file except for its space allocation, which is contained in the FAT. The data coded into these 32 bytes include the file name, extension, starting cluster, file size, time and date of creation. One byte is reserved to describe the file attribute. Hex '02' means the file is hidden, hex '04' designates a system file, and normal files have an attribute byte of hex '00'. More detailed information on the directory may be found in the DOS manual. At this point, we have enough information to look carefully at the rest of the Norton Utilities.

FILEHIDE - This utility controls the attribute byte associated with a file. It can hide a normal file, unhide a hidden one and can reset system files to normal and vice versa. Like all the other programs in the advanced utilities, FILEHIDE is entirely menu driven with the function and cursor keys, and a few minutes spent with the menu is all that is needed to use the program. Pressing F2 reads the directory information from a diskette and displays all files with their attributes. The directory is displayed with one file highlighted; choosing another file is just a matter of walking the highlight up and down with the cursor keys. F3 through F6 will switch the attribute byte; the change becomes permanent when written to disk with F9. There was a typo in the review copy: two of the menu entries (F4 and F6) are identical. F6 should actually read 'Reset System', not 'Reset Hidden', as F4 is really the 'Reset Hidden' function key. The program works in the same way as BATHIDE, except that the latter is specifically designed to be placed in a batch file. FileHide would be useful for accessing software which has been received as hidden files and for giving a nominal amount of protection to your own files.

UNERASE - This is another utility that one prays will never have to be invoked, but, in the event that accidental erasure becomes a reality, will have a price above rubies. It is best used in conjunction with DISKLOOK (see below), which will give the track and sector information needed to perform a rational recovery of the erased file.

When a file is erased, only two things really happen to it: the first letter of the file name is replaced by hex 'E5', which means that the directory entry is now available for use by another entry, and the allocated space in the FAT is considered free to be written on by other data. Therefore, if you have just accidentally erased a file, and have not done any other writing to the disk, it is no problem to recover the file in its entirety with UNERASE. In the event that you have written something else on the disk, it will probably be possible to recover at least part of the data.

It is strongly suggested that a few practice runs precede any attempt to reconstruct an accidentally erased file of priceless data. The documentation for this particular program was not quite as clear as it ought to be and, while using the

utility is not complicated, it requires strict attention and a good understanding of its function. In a situation where one is panicking at the idea of having just lost the entire year's profit and loss statement, it is advisable to procede with extreme caution.

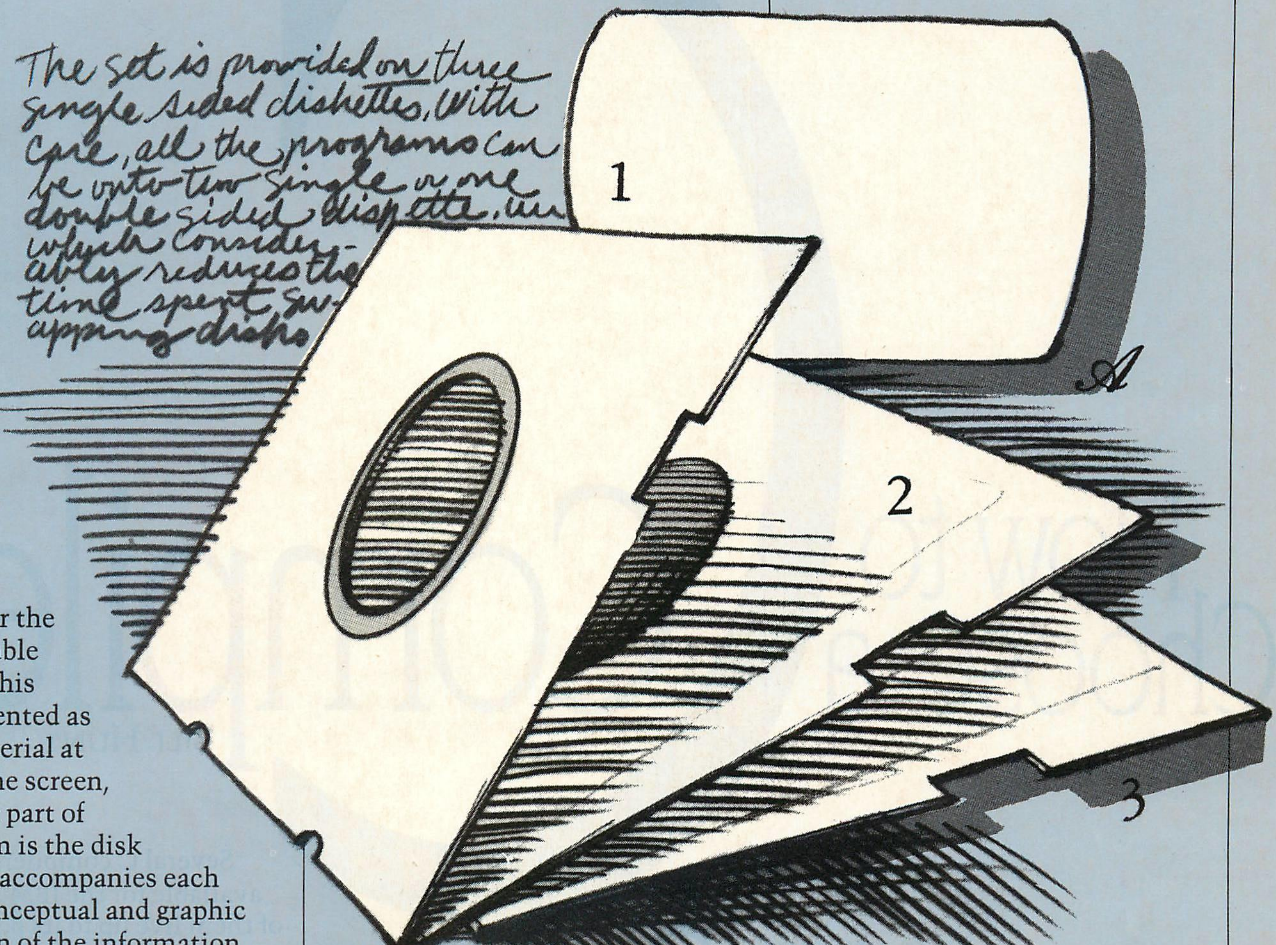
Recovering a file is done in three steps: choosing the desired file, selecting the file's data sectors, and inserting them in a reconstructed file to be saved to disk. Choosing the file is merely a matter of pressing F2, which will display all erased files on the disk. The first letter of these file names are all question marks, so the file is selected by the second letter. Once a file has been designated for recovery, UNERASE will display all of the data it knows about the file, like its size and condition of the first data sector. You then have the option of selecting sectors for recovery manually, or letting UNERASE do it for you. The data in each sector may be displayed in either hex or ASCII. This allows you to make sure that the sector you are about to save actually belongs to the file in question. At any time during the recovery process, you may review your progress and make sure that everything is proceeding as planned.

The reviewer tried out the program on an erased, outdated version of an old program, and it worked perfectly after the process became familiar. Again, this utility is one that will be priceless when needed and should have a place in the library of every PC user.

SECMOD - For you advanced programmers with a hexadecimal philosophy, SECMOD may become your favorite utility in this package. It allows the user to walk through any file, sector by sector, and change any of the information contained therein. To begin, you have the option of choosing either a file or a specific track and sector for browsing; the cursor keys are used to move from nibble to nibble or from sector to sector. The left side of the display is in hex, and the right side is in ASCII; the cursor may be changed easily from one to the other with the tab key. When the cursor is at the place to be changed, the new data is simply typed. All information so changed is highlighted, and no change is permanent until you write to the disk with F9. Once the change is made permanent, it is no longer highlighted. This is unfortunate, because if the change did not produce a desired result, it can be difficult to locate exactly where the last alteration began and ended. A hard copy of the screen can be made with the PrtSc key and the program is cleverly designed to strip unprintable characters off of this output. Having a hard copy is advisable, as it is easier to keep track of your revisions. The reviewer used SECMOD to change the DOS startup messages in the COMMAND.COM file to something a bit more personal but this utility has some obvious, less trivial uses, such as customizing packaged software for personal use.

The NORTON UTILITIES

DISKLOOK - This last program is the most unique, imaginative, enjoyable and educational one in the package. Again, entirely menu driven, it provides complete information on every file on the disk, including the name, directory number, size, creation date, attribute, starting cluster, track and sector



and whether the file is available or erased. This data is presented as textual material at the top of the screen, but the best part of this program is the disk map which accompanies each file. The conceptual and graphic presentation of the information is absolutely outstanding.

Pressing F2 gets the information from the disk, and then F9 will display all of the diskette information in the form of a complete map of all the space allocation on the disk, including bad tracks, conflicting allocations, usable areas, hidden system files and normal files. The vital statistics of the disk are displayed above the map and provide number of sectors and percentages of total sectors allotted to each type of file (system, hidden, erased, normal). F8 selects a specific file for display. F4 will show the file's directory information, and F5 and F6 will display its data in ASCII text line format or hex and character format, respectively. If you prefer, you can select a specific track and sector for display with F7 and then use F5 or F6 to browse through the sector. The disk directory can be sorted into ten different formats, five for normal files and five for erased files. This is extremely helpful in locating specific files for display with the other parts of the utility. Aside from providing valuable information about the condition of the disk, this program is fun to use and gives an insight into data organization which is worth the proverbial thousand words.

A considerable amount of thought went into the creation of this utility package. The human engineering is excellent and error recovery was impeccable. With the exception of one program, they all worked perfectly, and there were no unexpected or unpleasant surprises to be found anywhere. A nice addition to this package would be a stick-on label which could be placed on a blank section of the DOS Quick Reference Card. This would be in keeping with the manner in which the package follows the DOS philosophy on all other counts and would be a convenient conceit. The reviewer could but wish that Mr. Norton would try his hand at making the rest of the operating system as comfortable, attractive and easy to use as his Utilities are. □

CIRCLE NO. 280 ON READER SERVICE CARD

Dr. Glinert-Cole is a staff scientist at Ventrex Laboratories, Inc. and a regular contributor to Creative Computing *Magazine.*

How to Choose a C Compiler

Bill Hunt

IT IS UP TO THE PURCHASER TO SEPARATE THE SHEEP FROM THE GOATS WHEN BUYING A C COMPILER. HERE ARE SOME GUIDELINES FOR MAKING A SOUND DECISION.

Anyone who has used one of the better spreadsheet products or the Microsoft Flight Simulator knows that the IBM PC is capable of great things. But there is a wide gap between the sort of power and speed demonstrated in good software products and the results that an IBM PC owner can get using the BASIC interpreter. While the knowledge and technique of a professional programmer are a major part of this difference, a better tool than BASIC is also needed to make use of the PC's potential.

The C programming language is a good choice for developing software on the IBM PC. It is a practical language with a good balance of features and efficiency. An increasing number of PC software products are written in C.

Several C compilers are already available for the IBM PC. Not all of them live up to its potential. It is up to you as the purchaser to separate the sheep from the goats to make a good buying decision. This article gives some guidelines for evaluating C compilers.

Realistic Expectations

Before the IBM PC appeared, implementations of C on a personal computer were much less satisfactory than those on a minicomputer or a mainframe computer. The 64K addressing limit and the unsatisfactory processor instruction set of 8-bit microprocessors made major compromises necessary. The usual result was a compiler that omitted support for important parts of the language, compiled very slowly and produced programs that executed too slowly to be useful.

The IBM PC is a much better environment for compiling C programs and for executing C programs. As a result you can expect a good C compiler to come close to the level of performance and features available on larger computers. Here are some specific goals that *you should* expect to achieve:

- You should be able to edit, compile and link C programs without swapping floppy disks.
- The full C language should be supported.
- The library should include all standard I/O, string, character and memory allocation functions defined by Kernighan and Ritchie (reference 1).
- Compiling and linking small files should take less than two minutes.
- The compiler should produce native 8088 code. The compiled programs should be compact enough and fast enough for use in a software product.
- The compiler should allow programs as large as 64K bytes with an additional 64K bytes allowed for program data.

THERE IS A WIDE GAP BETWEEN THE POWER AND SPEED DEMONSRATED IN GOOD SOFTWARE PRODUCTS AND THE RESULTS THAT YOU CAN GET USING THE BASIC INTERPRETER.

How do I know that this wish list is attainable? I have been using a C compiler on an IBM PC for three months. It satisfies these requirements and gives me an environment for software development that is close to that of a $200,000 DEC VAX system with the UNIX operating system for about $7000.

There are some limitations of the IBM PC that do separate it from mini-computer systems. The limited disk capacity is much less convenient for working on projects that involve 10,000 or more lines of C source code. A C compiler for the IBM PC will probably be much slower than one running on a large computer for source files much larger than 400 lines. For one-person projects these limitations are not serious ones. Limitations of the 8088 processor architecture also make the IBM PC much less satisfactory for programs that need much more than 64K bytes of data.

Minimum Hardware Configuration

A good C compiler will require at least 128K bytes of RAM memory and two double sided diskette drives with 320K bytes capacity (or 360K bytes under DOS 2.0). While the compiler vendor may state smaller minimum requirements, the result will probably not be satisfying to use for a long period.

A hard disk may be necessary for projects involving more C source and object files than will fit on one floppy disk. Since this corresponds to 4000 or more lines of C source files, most C programs will fit in a floppy-disk only system.

Software to emulate a floppy disk drive and the ram memory you need to support it are available at attractive prices. A ramdisk can speed up the cycle of editing, compiling and linking C programs by at least a factor of two and increase the amount of on-line file storage. I recommend it highly.

A Checklist for Evaluation C Compilers

Table 1 lists some important criteria for evaluating C compilers. The following sections discuss these criteria.

Disk File Sizes

When you are developing C programs, you will spend lots of time using an editor, the C compiler and the DOS link program. Your life will be much more pleasant if you can keep all these programs available without changing floppy disks. If not, you will spend lots of time and energy juggling floppy disks. Find out the size of the compiler disk files and work out a strategy for fitting the compiler, editor and linker programs, and C source and object files on two floppy disks.

A sample layout of files is shown in Table 2. The disk in drive A is quite full—some DOS com-

mands were omitted to make it fit. But the disk in drive B has plenty of room for C source files and compiled and linked programs. This allows up to a maximum of 300K bytes of source and object files for a project to be kept together on one disk. Since this corresponds to at least 4000 lines of C source code, most projects will fit on-line on a floppy disk system.

Compiler Speed

You will be compiling C source files quite often. The faster the compiler finishes, the quicker you can get the job done. Fast compilation (and linking) is often more important than producing fast executing code.

The speed needed to compile and link a short source file of 50 lines is the most important test for a C compiler. The usual style of programming in C produces short source files; 50 to 100 lines is normal. A time of one or two minutes is acceptable. With a large ramdisk, my compiler requires only 40 seconds to compile and link such a file.

Compiling a file of 400 lines or more should be a rare event. A time of four to five minutes to compile and link such a file is acceptable. My compiler requires less than 90 seconds with a ramdisk.

Error Messages

Most PC owners have a slow printer or none at all. Waiting for a 50 to 100 line compiler output listing is a poor use of time. The compiler should help you to minimize the need for paper listings. Displaying syntax error messages on the screen with the source file line number helps. Identifying the source of an error with a statement number requires looking at a compiler output listing. Some compilers do not list the errors found on the screen but only in a listing file.

A human factor consideration is the way errors are handled by the compiler. Some compilers hang up or produce an avalanche of error messages when a syntax error is encountered. Poor error handling complicates the job of developing programs and is unacceptable.

DOS Programs

If the compiler accepts source files with the standard Carriage Return/ Line Feed end-of-line marker there should be no trouble using the editor of your choice. It is unlikely that this will be a problem, but it is worth a quick test.

Whether the compiler uses the standard DOS linker is a major question. If not, is the linker included with the compiler, or is it a separate cost item? Also, if a linker other than DOS's is used, how is interface with other languages (most importantly assembly language) achieved?

A GOOD C COMPILER WILL REQUIRE AT LEAST 128K BYTES OF RAM MEMORY AND TWO DOUBLE SIDED DISKETTE DRIVES WITH 320K BYTES CAPACITY—360K BYTES UNDER DOS 2.0.

Copy Protection

Copy-protected disks force you to swap disks every time you change programs. For compilers, copy-protected disks are unacceptable.

Support of the C Language Standard

It is certainly practical for a C compiler for the PC to support the full language and several available compilers do. You should not accept a compiler that omits any major parts of C.

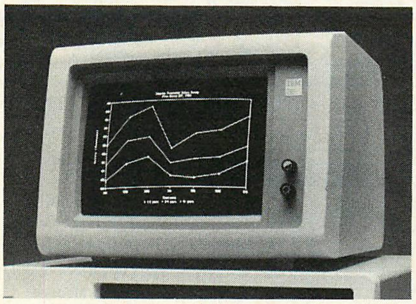
There are several reasons why the compiler should support standard C features. One is to allow you to compile and run existing C programs without modification. Another is to let you move programs you write to other computers. You also need the features in standard C to write efficient programs.

If you need to compile existing C programs, the only good solution is a compiler that supports the full C language as described in *The C Programming Language* by Kernighan and Ritchie (Prentice Hall, 1978). Any programs that use features that your compiler omits will have to be rewritten to avoid using those features. Then, moving your programs to other computers is less demanding. The worst sin that the compiler can commit is to alter the meaning of a feature that is part of standard C.

For programs that you write, some omissions are much more serious than others. The important omissions to watch for are

Structures - While structures are not used in all C programs, they are vital in some cases. C without structures is almost a toy language.

Long variables - Applications often require numbers that don't fit in 2 bytes even when it is not convenient for compiler writers.



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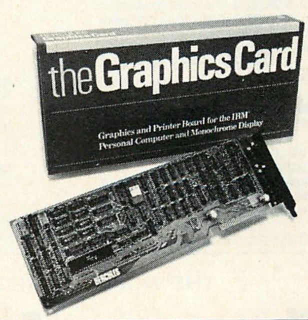

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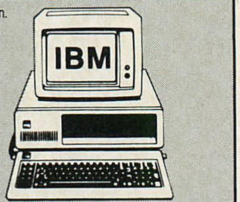

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Standard Library Functions

The standard C library includes functions for file input and output, manipulation of character strings, and memory allocation. A C compiler is not really useful without a library containing most of these standard functions, and it most likely will be unable to compile many standard C programs.

The functions described by Kernighan and Ritchie as part of the standard library are in table 3.

Documentation of the library functions is vital. They should be described with about one page per function. Source code for the library functions can be a great help when learning C. Those same source listings are also helpful if you build your own functions to replace library functions.

Expanding Beyond C and the Library

While C is very versatile, some things such as direct access to the PC hardware may still require assembler functions. The requirements for coding the assembler functions should be documented and examples provided.

And although you can write your own access functions in assembler, availability of such functions in the library can save you time and possibly allow you to avoid using assembly language altogether.

While the availability of a full standard library is an advantage, you will sometimes wish to produce programs that exclude library functions. Such cases include programs that do not require library support (but bring the library in to handle initialization), modules destined to become part of a larger program (DOS 2.0 device drivers are a good example), or programs for which a compact size is desirable. The compiler documentation should describe how to do this. It is often important and useful to replace the standard initialization code with your own version.

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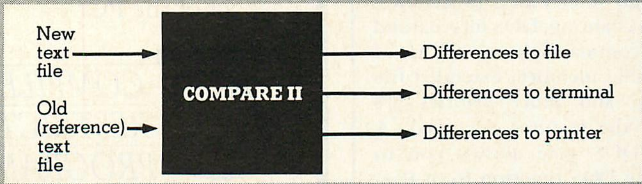

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HUNT: C COMPILER

Memory Usage

The compiler's handling of memory size, or its restrictions of same, are a major consideration. Some C compilers restrict the combination of program and data to a maximum of 64K. This is usually an unacceptable limitation. A better compiler will offer at least 64K for program and the same for data, and the best will be able to cope with the entire one megabyte address space of the 8088. The 64/64 split is a good compromise between capability and efficiency.

Pointers are widely used both in C library functions and in programs written by programmers. Their efficient implementation is crucial to the usefulness of C. While 32-bit pointers allow full access to the PC's memory, they are sometimes too inefficient. An acceptable compromise to the pointer problem is to provide library functions that access memory using a 32-bit address.

Finally, the compiler documentation should include information about the usage of the 8088 segment registers as an attempt to provide help with this often confusing aspect of the PC.

C COMPILERS THAT RESTRICT THE PROGRAM TO FIT IN 64K ARE UNACCEPTABLE BECAUSE THEY PREVENT C PROGRAMS FROM MAKING GOOD USE OF THE PC'S MEMORY CAPACITY.

Compatibility with DOS

The compiled C program must use the environment provided by the DOS operating system. The standard library should provide some special features for compatibility with DOS.

In the DOS environment, many programs use a pair of control characters, Carriage Return followed by Line Feed, to mark the end of a line in files of ASCII characters. Many existing C programs assume that a single control character, a Line Feed, marks the end of the line. To satisfy both the need for compatibility with other DOS programs and the need to accept existing C programs, the library should provide conversion between the two conventions as part of the standard I/O library functions. However, the library should also include some means for disabling this conversion when it is not desired.

Another convention used by programs in the DOS environment is marking the end of a file of ASCII characters by the single character control-Z (ASCII code 26). It is not part of the file's content and should be so recognized by the C standard I/O library. Once again, a means to disable this interpretation of the control-Z character should be available since it is part of the file's content in non-ASCII files.

DOS 2.0 provides enhancements such as hierarchical file directories that should be accessible from a C program. This requires that the library use DOS 2.0 function calls. Since DOS 2.0 is new, compiler vendors may require some time before their products are upgraded.

Performance and Benchmarks

The performance of the compiled program is just as important as the preceding criteria. If the programs you write are not compact and fast in execution, then you have not gained much over using BASIC.

The Compare II Story

as told by
L.L. "Bill" Packer
Director of Engineering
Solution Technology, Inc.

About a year ago, our company had a problem we solved by writing a utility program called COMPARE. I was asked to tell the story about how COMPARE evolved and why you might want to have your own copy. This engineering story spans about one year.

Early in 1982, Solution Technology, received a contract to implement a hard disk file server and database system using IEE-488 communications links and Digital Research's MPM-II operating system. Here's the kicker, the project had to be done between the first of February and the middle of April. In all, I had five programmers working on seven different computer systems; some with hard disks and some with floppies. With so many machines, programs and archive floppies involved, plus an around - the - clock work schedule, all normal source control methods were a joke. Our two biggest problems were; what was broken when a program used to work, and who changed what when two programmers "fixed" something? I tried a number of different conventional control systems that only held the problem at bay. In the end, the control problem became so acute that I assigned a couple of my best software engineers to come up with a way to compare two source files. Well, they designed a traditional file compare program called, naturally, COMPARE, and that program made our software control problem at least manageable. COMPARE 1.1 was effective but slow, so we ran it mostly on the hard disks.

COMPARE 1.1 was a useful program, but it needed work. First we had to remove the file restrictions so differences between files could be ANY number of lines long. Second, we needed the program to be able to compare the two input files in something less than an eternity. So back into the lab we went to see what software technology could be applied. We added a pinch of database philosophy and a dash of communications technique, and the result was COMPARE 1.2... a fast, line oriented file compare program which was very useful for programs and data files.

A short time later we were updating a technical manual for another contract and had to put change bars in each new issue to tell the end user where the changes were. Since text updates had been made by a number of people at different times, we attempted to use COMPARE 1.2 to locate all the places that had been changed. While somewhat successful, we still had to draw the change bars by hand. This was a huge waste of time because the process had to be repeated for every new issue. Enough! Time is money, so back into the lab. First to add word by word scanning and second, to be able to generate change bars automatically. Again success! We created COMPARE 1.3.

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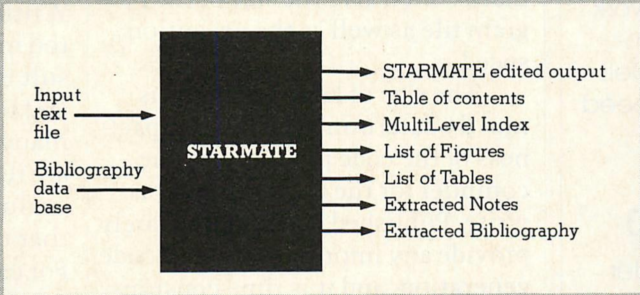

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There are three different kinds of performance that are important for C programs.

The amount of RAM memory required for execution is important for large programs but the amount of disk space required to store the program is more important. For small to medium C programs the program size is mostly determined by the number of library functions that must be linked with the program. Since on-line storage is in short supply on the IBM PC, small programs are much more desirable than large ones. Published benchmarks often give the size of the program file as well as the execution speed.

The size of large programs is mostly determined by the compactness of the code produced by the compiler for the C functions you write. Published benchmarks rarely provide any information about code generation, and it is time consuming to study the matter during the buying process.

Finally, while measurements of execution speed on benchmark programs have been reported for a few C compilers, the benchmarks used have not been very relevant. It is important to identify often-used and performance-critical language features and to build a benchmark that represents them well. For C the features that are most important are these:

Function calls - If the cost of calling a function is too high, programs with many small modular functions will perform more poorly than they should.

Loops - In many programs, most of the execution time is spent on a few lines of C inside a WHILE or FOR loop.

Pointers and array subscripting - The time-consuming loops in a program usually involve arrays or pointers.

Execution speeds for C programs will probably vary by a factor of four between the best and worst C compilers. While this range is significant, the meager benchmark information available will not allow you to make a clear choice based on performance. The best policy is to emphasize other criteria in choosing a compiler.

Further Advice

In addition to the criteria in Table 1, here are some additional things to look for.

Signs of Overall Quality

Writing a compiler does not require too much effort, but turning the result into a finished product is a long and tedious task. The result is that many compilers are written but few are really done well. When you evaluate a compiler, look for signs that the vendor cut some corners. For each example of corner-cutting you find when you evaluate a product, you will discover several more after you buy the product. The quality of the product literature and the product documentation is a good indicator of the product's overall quality.

Separate Compilation

C encourages a style of programming with many short functions packaged in files of 50 to 400 lines. Compiling these files separately and linking them to produce the

EXECUTION SPEEDS FOR C PROGRAMS WILL VARY BY A FACTOR OF FOUR BETWEEN THE BEST AND WORST.

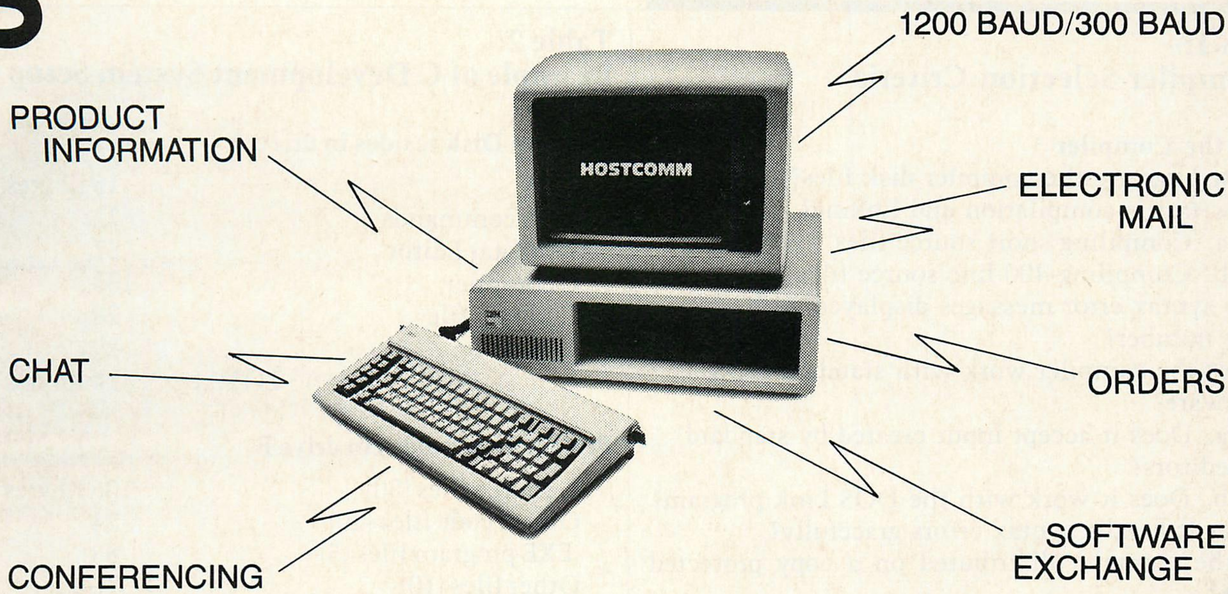

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Table 1: C Compiler Selection Criteria

Using the Compiler

1. How large are the compiler disk files?
2. How fast is compilation and linking?
   a. Compiling short source files
   b. Compiling 400-line source files
3. Are syntax error messages displayed with a line number?
4. Does the compiler work with standard DOS software?
   a. Does it accept input created by standard editors?
   b. Does it work with the DOS Link program?
5. Does it handle syntax errors gracefully?
6. Is the compiler distributed on a copy protected disk?

Language

1. Does the compiler support the full C Language?
2. Are there any major omissions?

Standard C Library Functions

1. Are the standard C Library functions provided?
2. Is usage of the library functions well documented?
3. Is a source listing provided for library functions?

Expanding Beyond C and the Library

1. Is an interface provided for assembler functions?
2. Does the library include DOS and BIOS access functions?
3. Is a procedure provided for excluding library functions?

Memory Usage

1. How much memory can the C program occupy?
2. How much program data can be used?
3. Are C pointers represented by 16 or 32 bits?
4. Are functions provided for memory access using a 32-bit address?
5. Is usage of the 8088 segment registers documented?

Compatibility with DOS environment

1. Does the library do conversion of end-of-line markers?
2. Can conversion of end-of-line markers be disabled?
3. Does it sense the control-z char as an end-of-line marker?
4. Can control-z sensing be disabled?
5. Does the library support DOS 2.0 functions fully?

Table 2: Example of C Development System Setup

Program Disk resides in drive A

DOS	15 Kbytes
DOS commands	22
Wordstar Editor	87
C compiler	133
C library file	28
Linker	29
TOTAL	314 Kbytes

Project disk resides in drive B

C source files (50)	106 Kbytes
Object code files (20)	24
.EXE program files (5)	88
Other files (10)	16
TOTAL	234 Kbytes

Table 3: Kernighan & Ritchie Library Functions

File I/O

fopen, fclose
getc, putc, ungetc
getchar, putchar
fseek, ftell
fprintf, fscanf, printf, scanf
gets, puts, fgets, fputs
sprintf, sscanf

String Manipulation

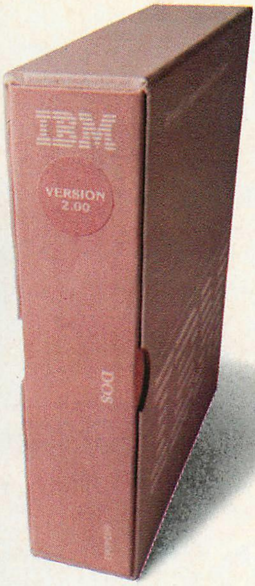
strcpy, strcmp, strcat, strlen

Memory Allocation

alloc, calloc, free

Character Conversion

isalpha, isupper, islower, isdigit, isspace
toupper, tolower



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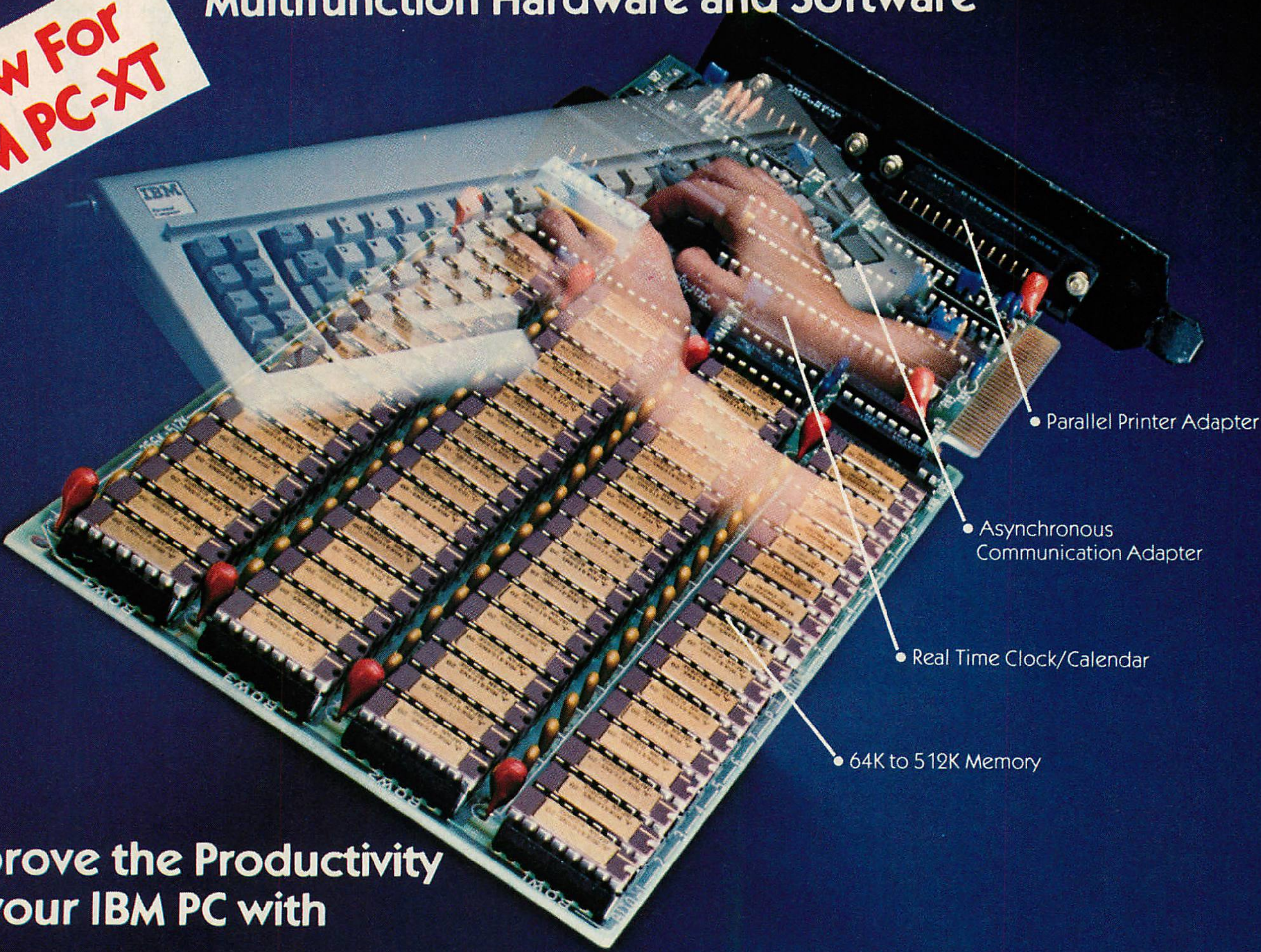

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complete program is a major improvement over the monolithic programs of BASIC or standard Pascal. Any C compiler that does not support separate compilation is unacceptable.

ASSEMBLY CODE GENERATORS
Many compilers produce object code files which are ready for the linker. This is the right way to do the job. Some compilers rely on a separate assembler program to finish the job of generating object files. This is an unsatisfactory method for several reasons:

- The assembler step is usually quite time consuming. This is especially true for the Microsoft Assembler marketed by IBM.
- The assembler is another program to be squeezed into scarce on-line space. If the assembler will not fit on the compiler diskette, you must either swap diskettes after every compilation or assemble a group of modules after they have all been compiled; both techniques are awkward.
- More temporary file space will be required. Each line in the C source file will produce three or four lines of assembly language output.

The usual justification for this approach is that the programmer can inspect the file that the compiler outputs and hand-tailor parts of it to improve performance. Such hand-tailoring is very perishable: when the C file is recompiled the

(continued on page 177)

List of Available C Compilers

Company Name	Product Name	Price
Intellect Associates P.O. Box 365 Holbrook, N.Y. 11741 CIRCLE NO. 295 ON READER SERVICE CARD	C88	$150
c-systems P.O. Box 3253 Fullerton, CA 92634 (714)-637-5362 CIRCLE NO. 296 ON READER SERVICE CARD	c-systems C	$195
Computer Inovations 75 Pine Street Lincroft, New Jersey 07738 (201)-530-0995 CIRCLE NO. 297 ON READER SERVICE CARD	C86	$395
Telecon Systems 1155 Meridian Ave. #218 San Jose, CA 95125 (408)-275-1659 CIRCLE NO. 298 ON READER SERVICE CARD	Telecon C	$350
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Tinkering with DOS 2.00

PUTTING COMMANDS IN YOUR OWN LANGUAGE AND AVOIDING SABOTAGE IN THE PROCESS.

PETER NORTON

Just about the first thing that I do when I get a new release of the PC DOS operating system is change it to make it easier to enter the time.

This might seem a strange thing to do, but I have my reasons, part pride and part practical. The practical reason is that I think it is a very good idea to always give DOS the correct date and time, so that the time-stamps on files are accurate. But DOS makes it a nuisance to enter the time, since a colon is used to separate the hour and minute, so I like to modify DOS's COMMAND.COM to use a hyphen in entering the time. The hyphen is right on the top row of the keyboard next to the numbers (and also next to the 10-key pad) so it is a lot easier to type the time with a hyphen, and it is consistent with the way we enter the date. The pride reason for making this modification to DOS is that it gives me a small sense of having mastered at least a small part of DOS's internal structure.

After some exploration, I cracked DOS 2.00's way of controlling entry of the time. Oddly enough, time entry at DOS's "boot," and time entry at the TIME command, are controlled by different parts of the program, 32 bytes apart; isn't that a curiosity?

Here is quick summary of how to make the change:

- Format a system disk, in drive B:

  FORMAT B:/S
- Load the DEBUG tool, and tell it to read COMMAND.COM from drive B:

  DEBUG

  B:COMMAND.COM
- Give DEBUG these two instructions, which move two hyphens (ASCII code 2D) into place in two different locations:

  F 2999 L 2 2D

  F 29B9 L 2 2D
- Tell DEBUG to write back the modified COMMAND.COM, and exit:

  W

  Q
- Now, test the result. Put the modified diskette in drive A, and boot (Ctrl-Alt-Del). DOS should now require a hyphen when you enter the time.
- If all is well, copy the new COMMAND.COM to your various system disks for DOS 2.00.

There are many kinds of tinkering that you can do with DOS. If you're good at assembly language coding, and really want to get into it, you can use the DEBUG unassemble command, U, to display parts of DOS for analysis. Then, if you know what you are doing, you can code up modified versions of DOS. Here are some that you might want to play with, and a few warnings.

In COMMAND.COM you might want to change the DOS starting messages that read "The IBM Personal Computer DOS. . .". These two messages can be safely changed to anything that will fit into the same space: your name, your company's logo, or a system name, for example.

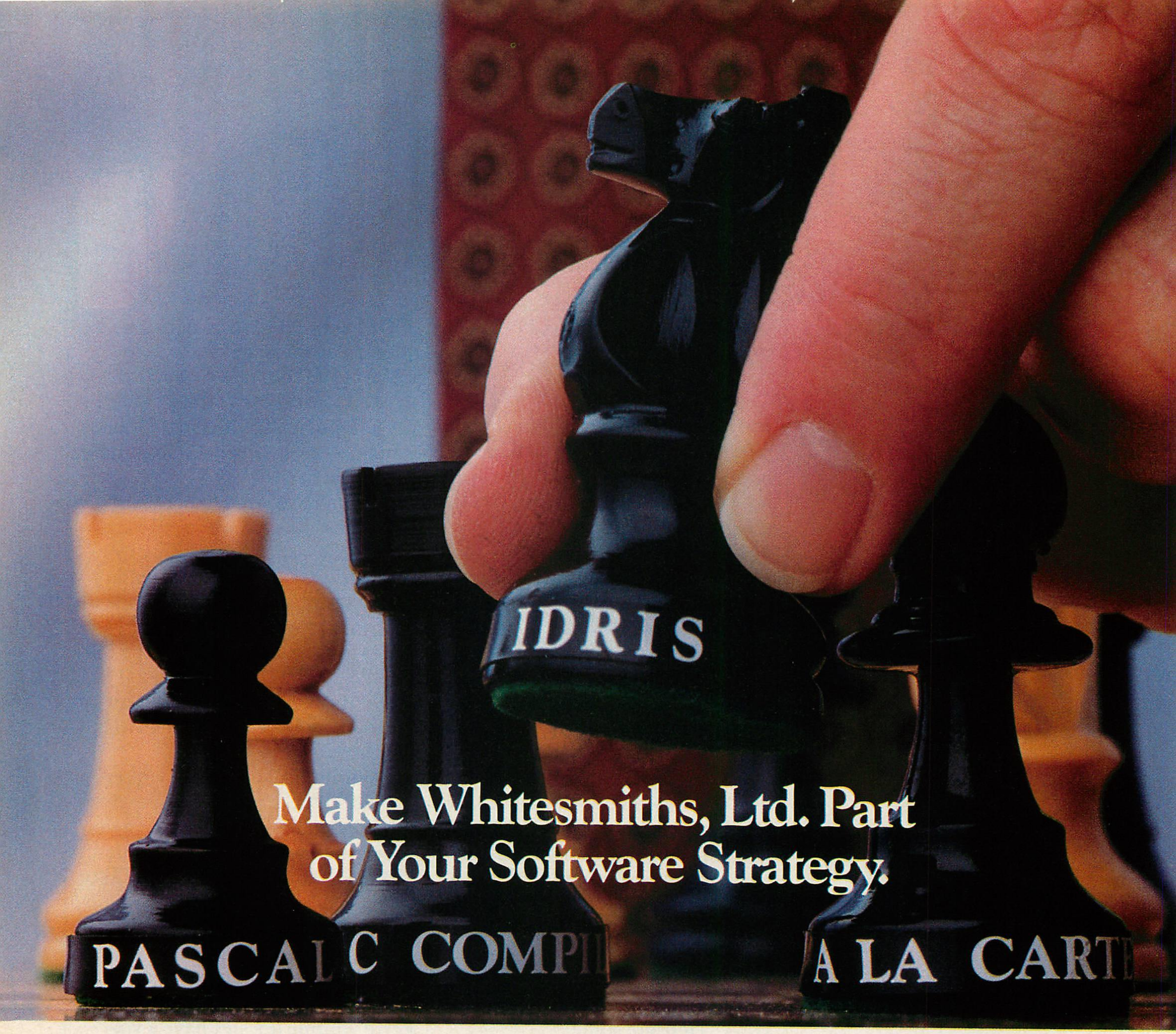
When you use the DIR command to get a directory listing, subdirectories are indicated, inelegantly, by the message "⟨DIR⟩" but if you look inside of COMMAND.COM you'll find that there is space where this message is stored to change it to "directory," spelled out in lower case. I made this change to my COMMAND.COM, and found it makes the directory listings more attractive to the eye.

If you're like me, you prefer most messages to be presented in lower case—they look more attractive and less authoritarian. (I don't like to feel my computer is trying to bully me.) There is a particularly obnoxious one that is issued by the TREE.COM command, which I'll leave to you to discover. As soon as I saw it, I had to get inside and make it more friendly.

While this business of tinkering with DOS messages is pretty safe, there are three things that you should be warned about. First, don't change anything that says PATH or COMSPEC in capital letters—changing these can sabotage DOS. Also, you'll find that DOS is fond of using a string of eleven question marks when reporting that a diskette volume doesn't have a volume id label. This is so obnoxious that you may be tempted to change it to something like "no label," but don't; changing some of these question marks can interfere with DOS's fussy operation. And the final warning is that if you change COMMAND.COM, and then copy it to the system disk that you are currently using, you may have to re-boot—since whenever DOS reloads COMMAND.COM, it checks to see if it is the same as the copy originally used.□

CIRCLE NO. 281 ON READER SERVICE CARD

Peter Norton writes books and programs for the IBM PC. His book, "Inside the IBM/PC" was recently published by The Robert J. Brady Co. His utility programs for the PC, called the Norton Utilities, have received wide praise (see our review on page 70).



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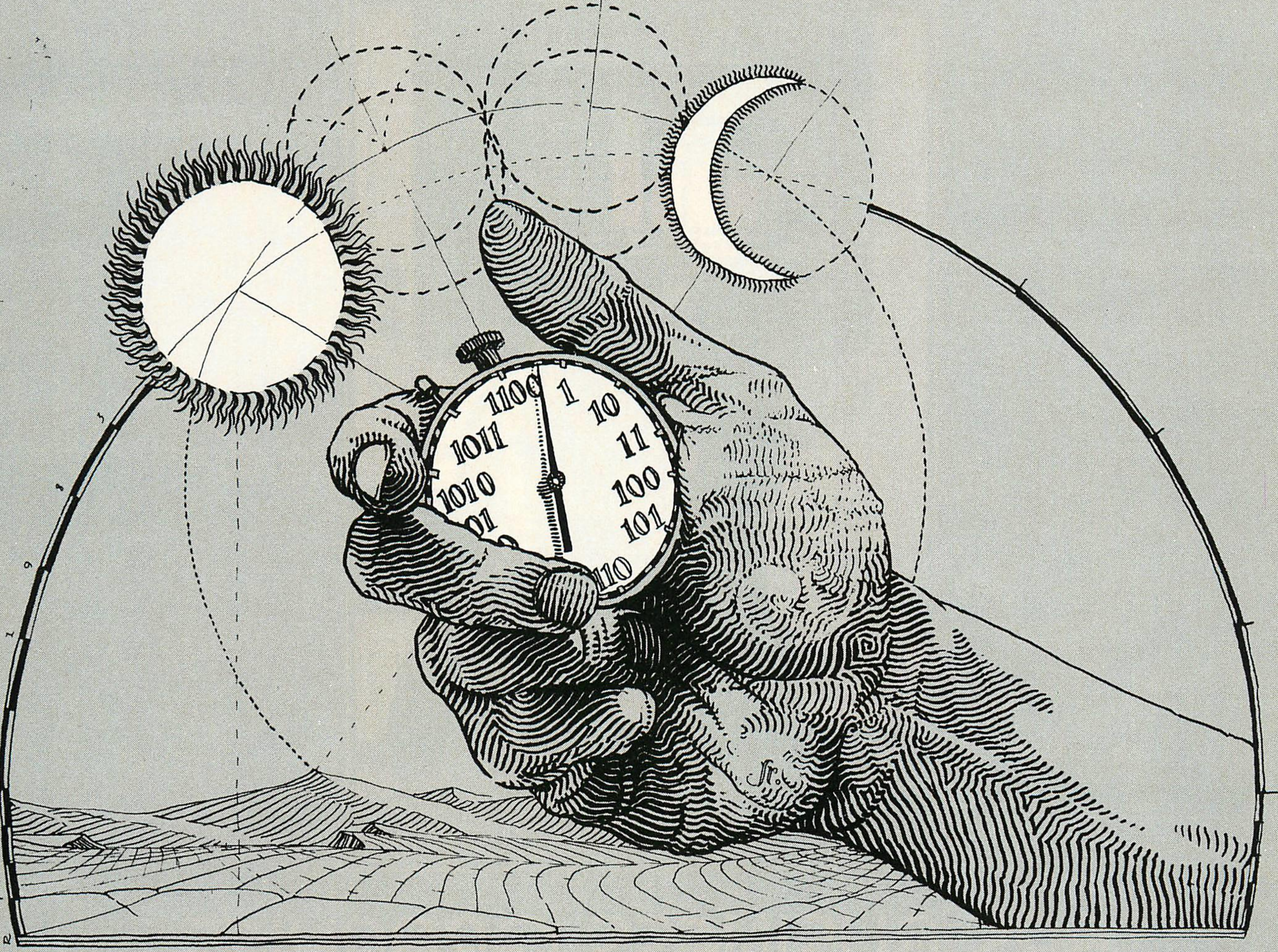


A·DIVERSIONARY BENCHMARK

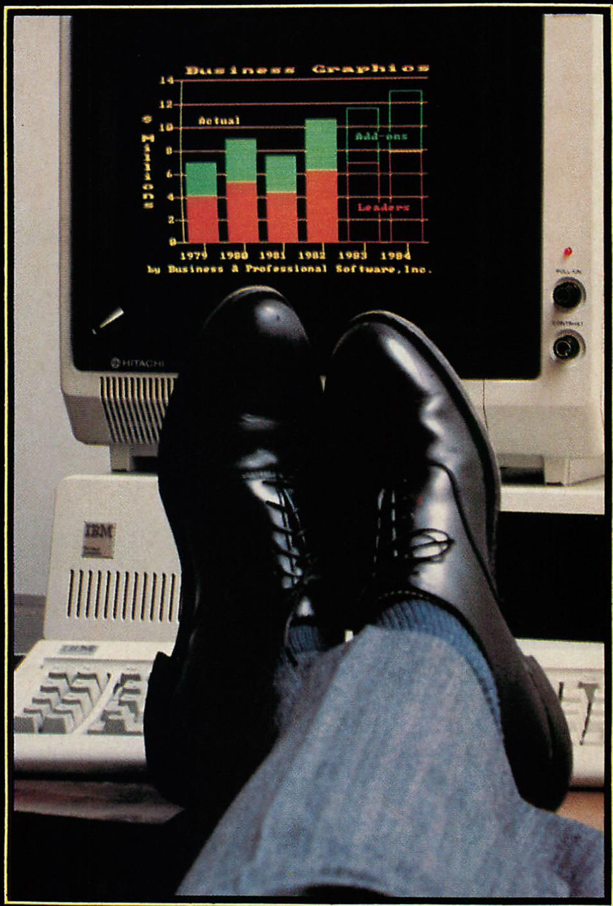
AN INTERESTING PROGRAM REVEALS PC PERFORMANCE CHARACTERISTICS

SUSAN GLINERT-COLE

It is a common joke in some research and development laboratories that it is always possible to force data points onto any type of curve by choosing the appropriate type of semi-logarithmic graph paper. Benchmarks have some of the same flavor of this type of data manipulation—often benchmarks are a better indicator of ability of the investigator to twiddle numbers than provide meaningful information on a given subject. While I was writing this article, one Stephen Pickett remarked to me that there are "lies, damn lies, and benchmarks."

(continued on page 97)

Relax.



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(continued from page 95)

The biggest problem with benchmarks is that the underlying parameters with which they are executed must be completely defined for the results to be a true measure of the speed or efficiency of the system in question. This is often difficult to do, because operating systems, languages, and processors often excel in some aspects of computation or data handling and are inadequate or sub-optimal in others. Programs written in any assembler language, in general, are finished running while the same program written in BASIC is still fumbling around with the first few lines of code. It is therefore important to have the benchmark as general as possible in the sense that it will use, insofar as is possible, functions that all computers have in common. This rules out any program that is input/output bound or uses exotic features of a particular machine that are not available on any other except through programming contortions.

The most common benchmark program to which a computer and its software are subjected is the Sieve of Erastosthenes, that generates prime numbers by sifting out multiples of integers until the only remaining numbers are divisible by one or itself. The Sieve has all the qualities that contribute to a good benchmark: the code itself is usually quite short, which minimizes problems with storage and compile time, it is not I/O bound, it uses integer arithmetic, and it doesn't rely on any unusual features of a particular system. Further, the output, a series of prime numbers, does not vary in any way from system to system, making interpretation of the results independent of the operator. In fact, the only requirement for running this benchmark is a computer and a good stopwatch.

THE ONLY REQUIREMENT FOR RUNNING THIS BENCHMARK IS A COMPUTER AND A GOOD STOPWATCH

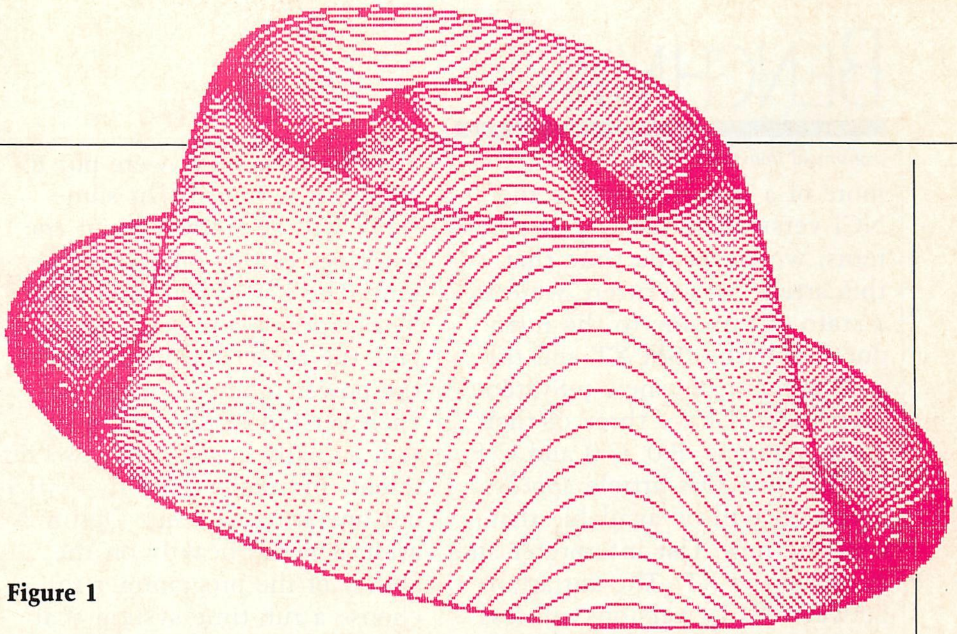

Figure 1

The benchmark described in this article shares only one feature of the Sieve program: it's short. In almost every other way, it deviates from the accepted idea of a benchmark program. It uses real numbers, and is therefore dependent on the real word size used. It computes a great many sines, and so uses transcendental library functions, which are almost always unique to each language. The output is a screenful of graphics, and is therefore subject not only to the units in the language that generate these graphics, but on the quality of the video monitor being used. A modicum of aesthetics therefore enters into the final evaluation.

As can be seen from the listings, the code itself is short and pithy. One pass through the outer loop generates a single point that is plotted onto the screen; the end result is a rather charming pink fedora (figure 1). The underlying routine, which was taken from an old advertisement by MTI, is useful for getting a feel for drawing complex surfaces and can be adapted to many complex and interesting applications. It also gives a very good feel for the graphic resolution of the IBM PC in comparison with other graphic generating computers.

Most of these benchmarks were run by Stephen Pickett and his associates at Network Consulting Incorporated. They are

THE LIST OF BENCHMARKS IS BY NO MEANS COMPLETE, BUT WILL GIVE THE READER A GENERAL IDEA OF THE POWER INHERENT IN THE 8087.

(continued on page 98)

(continued from page 97)

more of a commentary on the NCI versions of the UCSD p-Systems, which, at the time that this article was written, were in a state of flux due to the introduction of the IBM XT and the development of a new p-System interpreter. I have three of their latest versions, B.0, C.0 and C.1. By the time this article appears, a version will be available that uses the new, fast interpreter and supports the XT. The variations between NCI's versions are less important than the impact that the use of the 8087 numeric coprocessor makes on the speed with which the hat appears.

This article is also intended to provide some insight into the workings of the p-System. Each benchmark required a hand-tooled configuration and, in explaining how these were put together, it is hoped that something will be learned about the workings of this operating system. The list of benchmarks is by no means complete, but will give the reader a general idea of the power inherent in the 8087. Each version of the NCI p-system actually comes with two different interpreters and two different operating systems. Optimization depends heavily on the ability of the programmer to choose a run-time system that gives the best performance for a particular application. Floating point support is provided for both two- and four-word reals; each word size may further be supported with the appropriate 8087 driver. In addition, it is possible to convert parts of a p-code program to native code for either the 8088 or the 8088/8087 combination. (We will ignore in this article the long integer option.) It is possible to support two-word reals in a four-word environment by using the unit Two-Word. To make matters slightly more complicated, there is a Turtlegraphics unit for each configuration.

The Realops unit must be present in the system library. It provides I/O support for real numbers (read real, write real), real constant conversion, and transcendental functions. To duplicate these benchmarks, the system disks must contain the following units and system files:

Two Word Reals:
Interp2, Turtle2, Realops2

Two Word Reals + 8087 Support: Interp27, Turtle27, Realops27

Four Word Reals: Interp4, Turtle4, Realops4

Four Word Reals + 8087 Support: Interp47, Turtle47, Realops47

It should be noted that the file

BENCHMARKS ARE OFTEN A BETTER INDICATOR OF ABILITY OF THE INVESTIGATOR TO TWIDDLE NUMBERS THAN PROVIDE MEANINGFUL INFORMATION ON A GIVEN SUBJECT.

(continued on page 116)

Table 1 - FOUR WORD REALS

System	Time (minutes:seconds)
IBM IV.03 p-System (from Softech)	215:00
NCI IV.1 C.O p-System	39:00
NCI IV.1 C.O + 8087 support	16:30
NCI IV.1 C.O + 8087 and direct support for SIN and SQRT in REALOPS unit	5:05
NCI IV.1 C.O + 8087 support and native code generation	3:43

Table 2 - TWO WORD REALS

System	Time (minutes:seconds)
1. IBM IV.03 p-System (from Softech)	69:00
2. NCI IV.1 B.1 p-System	22:16
3. NCI IV.1 C.O	21:37
4. NCI IV.1 C.O. + 8087 support	13:10
5. NCI IV.1 C.O + 8087 and direct support for SIN and SQRT in REALOPS unit	4:52
6. NCI IV.1 C.O + 8087 support and native code generation	3:35
7. IBM interpreted BASIC	45:30
8. IBM Compiled BASIC	11:28

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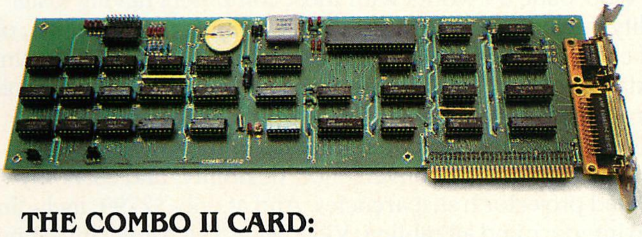

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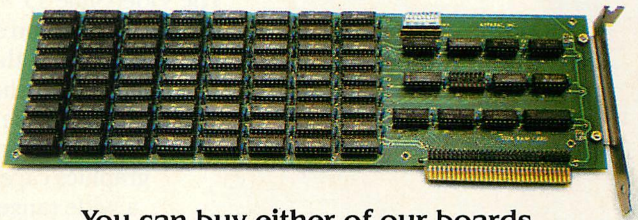

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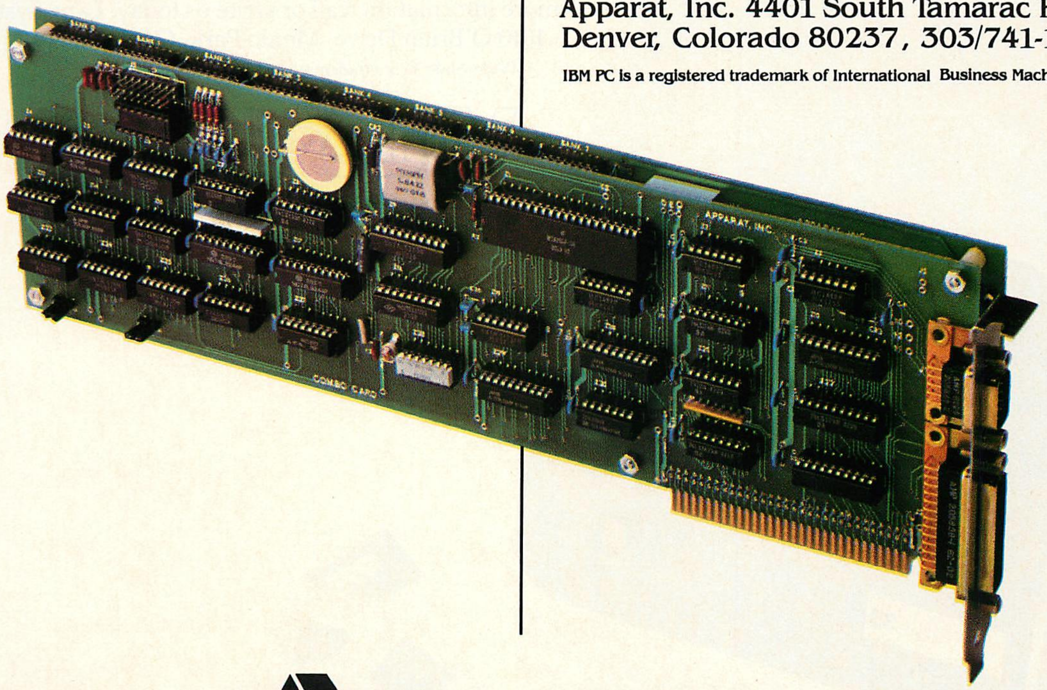

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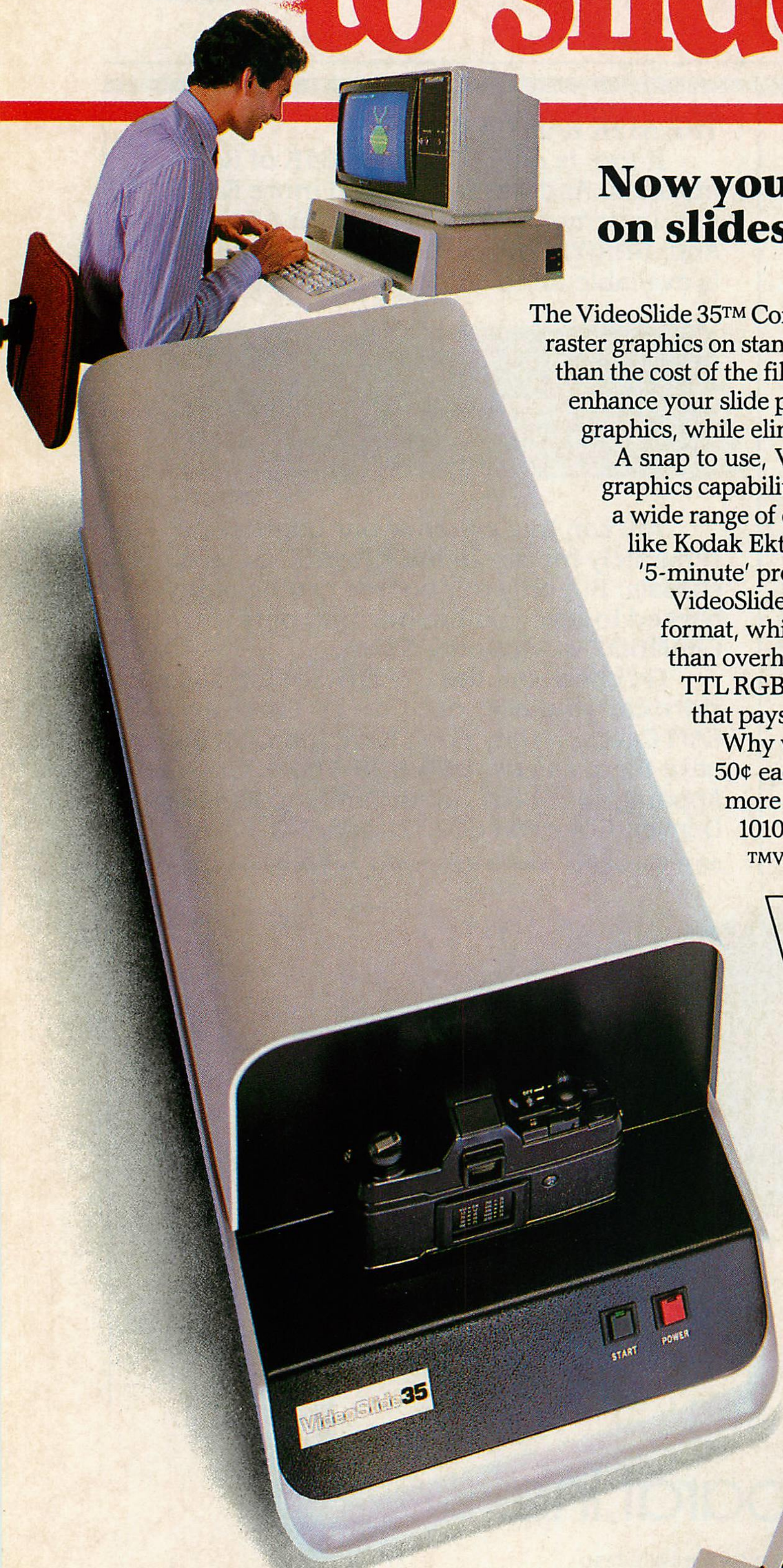

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Controlled Plotting Using the IBM PC

THE AVAILABLE 640 X 200 DOT ADDRESSABLE MODE ENABLES A PROGRAMMER TO DEVELOP PLOTTING SYSTEMS THAT EMPLOY RELATIVELY SOPHISTICATED TECHNIQUES.

THOMAS HOCKSWENDER

The IBM Personal Computer, coupled with the high resolution capability of the Color/Graphics adapter allows for the use of generalized approaches to graphics that were previously applied to high speed raster scan equipment. The available 640 x 200 dot addressable mode (via the Screen 2 command) enables a programmer to develop plotting systems that employ relatively sophisticated techniques. This short article examines some of these techniques and demonstrates their utility on the PC.

In general, any two dimensional graph consists of a range of X and Y values that are bounded by defined maxima and minima. This data region, D, must then be transformed onto a desired screen window, W, of the display unit (television, monitor or even a plotter). This screen window will also have definite limits that are defined as a subset

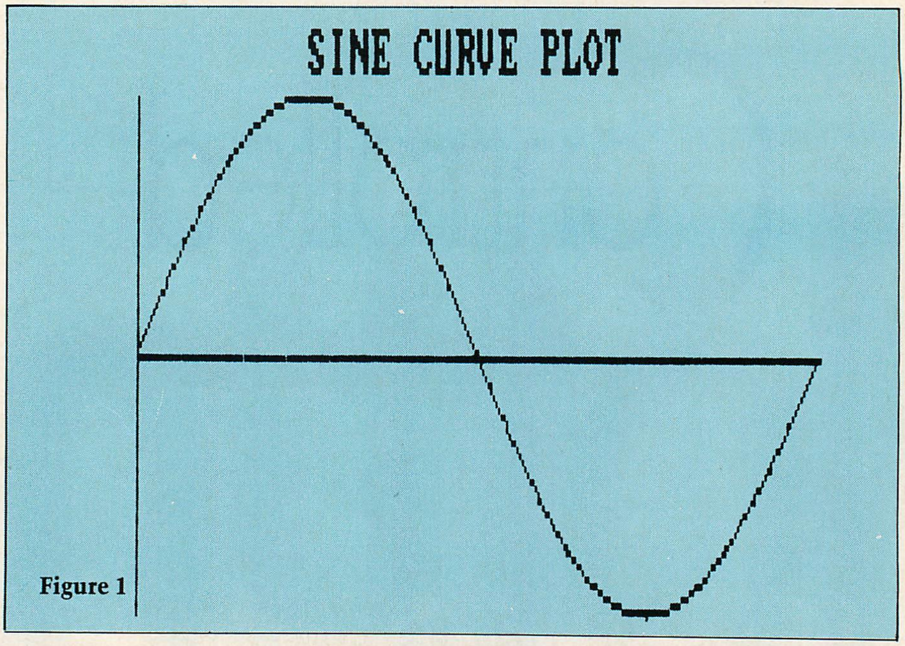

Figure 1

of the entire display. The specific points on the display have the limits established by the hardware.

To be specific, the PC established the values of 0 to 639 for the horizontal range and 0 to 199 for the vertical range. The graphics problem can be stated in terms of developing the appropriate linear transformations of the data into specific horizontal and vertical coordinates. Following the treatment given by Chambers, ("Computational Methods for Data Analysis," Chapter 8,

THE ACTUAL PLOTTING IS FAIRLY RAPID BECAUSE THE SLOW STEP OF EVALUATING THE SINE FUNCTION IS DONE ONLY ONCE AND PLACED IN A DATA ENTRY.

John Wiley and Sons, New York, 1977) schematic forms of the two dimensional arrays are

$$D = \begin{bmatrix} D(1,1) & D(1,2) \\ D(2,1) & D(2,2) \end{bmatrix} \begin{bmatrix} \text{XMIN} & \text{XMAX} \\ \text{YMIN} & \text{YMAX} \end{bmatrix} \quad \text{DATA SPACE}$$

$$W = \begin{bmatrix} W(1,1) & W(1,2) \\ W(2,1) & W(2,2) \end{bmatrix} \begin{bmatrix} \text{HORIZONTAL} \\ \text{VERTICAL} \end{bmatrix} \quad \text{SCREEN WINDOW}$$

$$R = \begin{bmatrix} R(1,1) & R(1,2) \\ R(2,1) & R(2,2) \end{bmatrix} \begin{bmatrix} 0 & 639 \\ 0 & 199 \end{bmatrix} \quad \text{HARDWARE LIMITS}$$

The points to consider here are that the above hardware limits are expressed in a Cartesian coordinate system while the PC coordinate along the vertical axis is zero at the top and 199 at the bottom and that this treatment was derived for a vector graphics system. In order to calculate the screen positions in the more familiar system the R matrix is written as:

$$R = \begin{bmatrix} 0 & 640 \\ 200 & 0 \end{bmatrix}$$

This accommodates both the coordinate change and the vector notation. Carrying through the transformation equations leads to:

T11 = R11 + W11*(R12-R11) - T12*D11
T12 = (R12-R11)*(W12-W11) /(D12-D11)
T21 = R12 + W21*(R22-R21) - T22*D21
T22 = (R22-R21)*(W22-W21) /(D22-D21)

where the shorthand notation for the matrix elements should be obvious. Once these equations have been developed, the actual horizontal and vertical screen (or plotter) positions are given by:

Horizontal = T11 + T12*X.DATA.POINT
Vertical = T21 + T22*Y.DATA.POINT

The actual display will be produced according to the language employed, but the entire discussion above is not language dependent.

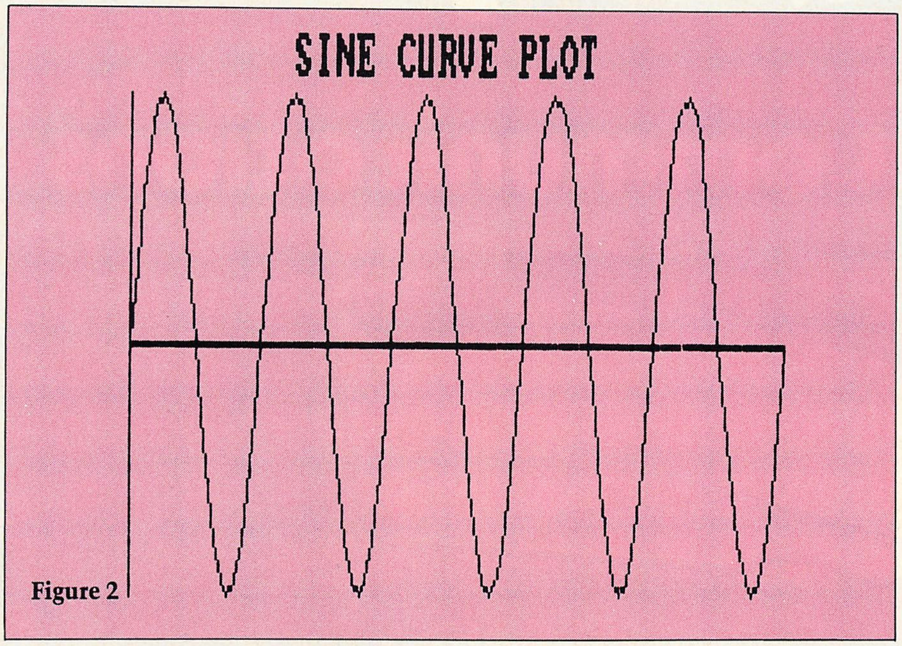

Figure 2

The information required consists of the maximum and minimum values for the function arguments, the function, the screen window and the hardware limits.

A good demonstration of this is given in Listing 1, a routine designed to first plot a sine curve, with axes and a label, in the center forty percent of the display and then to plot four additional curves in each of the corners. Figure 1 is a dump of the actual graphics screen.

There are several points of interest in the Listing. The actual plotting is fairly rapid because the slow step of evaluating the sine function is done only once and placed in a data array. The size of this array is related to the desired resolution of the plot across the widest display screen chosen - no problem occurs with its use for the smaller curves. Since only the screen window parameters change for each plot it is easy to see how a suitably designed routine can allow a user or programmer to define several windows then pick the most appropriate.

This approach to plotting also allows for an easy choice of window area to give the desired aspect ratio. This refers to the differences between the horizontal and vertical dimensions of various display devices versus the range of X and Y values for a function plot. Change these parameters in the Program and observe the change in plot shapes.

THE GRAPHICS PROBLEM CAN BE STATED IN TERMS OF DEVELOPING THE APPROPRIATE LINEAR TRANSFORMATION OF THE DATA INTO SPECIFIC HORIZONTAL AND VERTICAL COORDINATES.

For those who are interested in this approach to plotting but would like to maximize the plotting speed and resolution I would suggest you attempt to use the LINE and SWAP commands of the PC. Use the program from Listing 2 instead and the plot shown in Figure 2 containing five times as much information will be drawn twice as fast as the simpler graph of Figure 1. □

Listings for this article are to be found on pages 194, 196.

Thomas Hockswender, a Ph. D. in chemistry, is a senior research associate at Pittsburgh-based PPG Industries.

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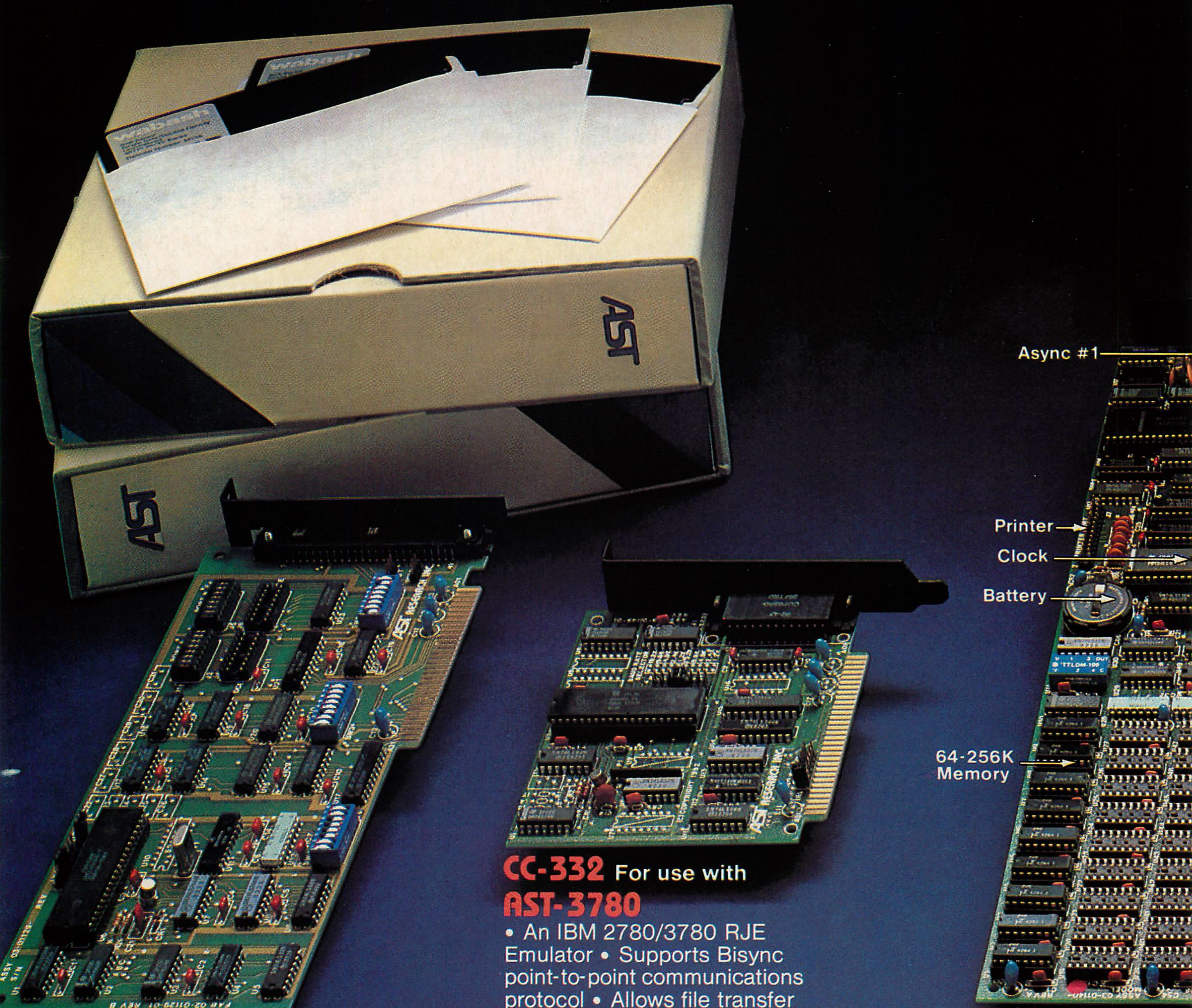

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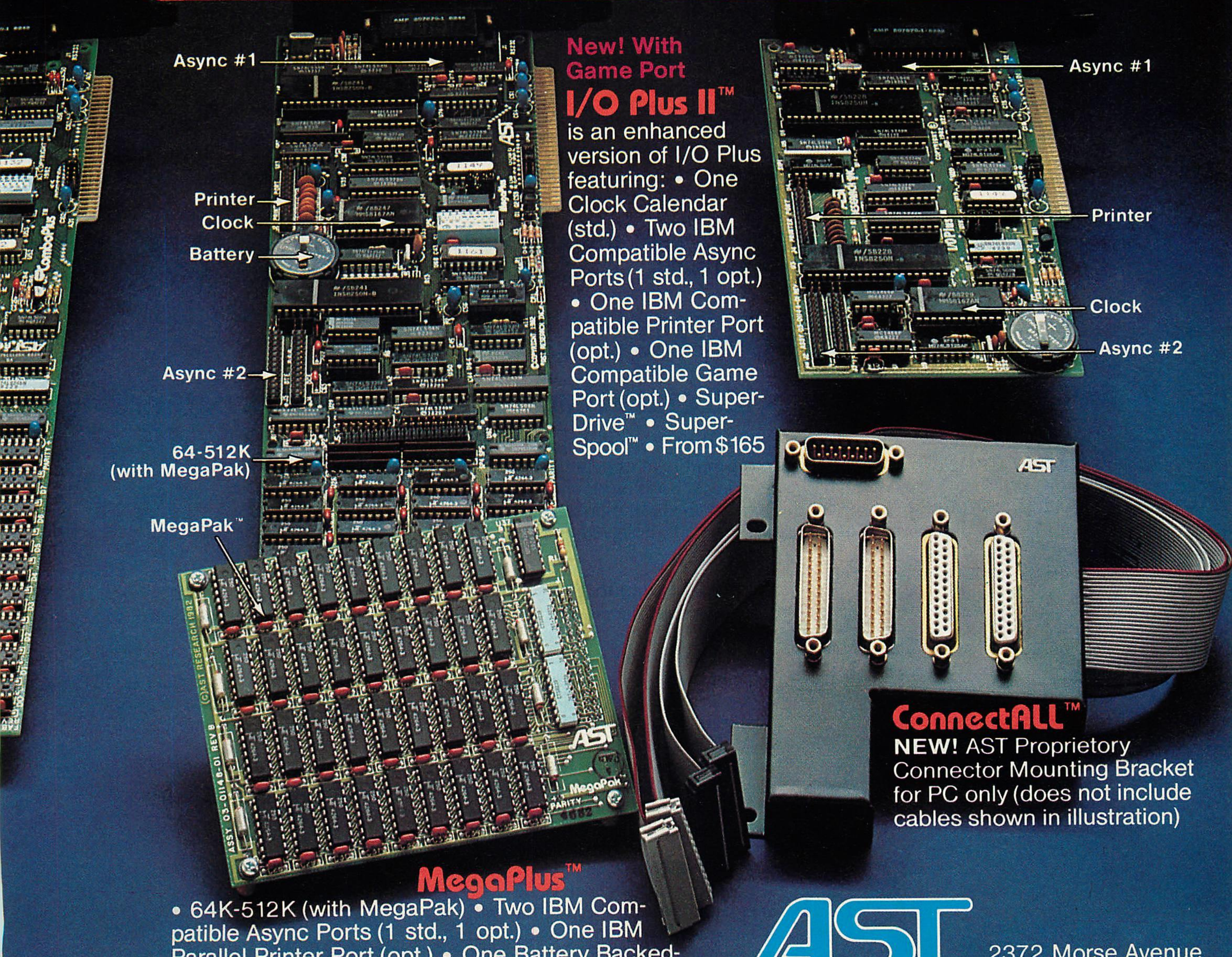

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Don Awalt

Software Review

IBM's BASIC PROGRAMMING DEVELOPMENT SYSTEM

AS A TOOL FOR MAKING BASIC MORE STRUCTURED, IT COMPARES POORLY

With the success of the IBM Personal Computer in the last year and the recent introduction of the XT Model, IBM is very well established in both the business and home use of its microprocessor-based computers. As with most personal computers, BASIC is the language provided initially. To assist this large market of BASIC users, IBM has introduced the BASIC Programming Development System, part of the IBM Personal Computer Language Series. At a price of $130, it compares poorly to the other programming development software available to PC BASIC users.

There are many software packages on the market today that offer different types of BASIC development support. The reason these packages are becoming common is that there is a real need for tools that make BASIC a more structured language. Using a more structured form of BASIC can be important. Enhancement and maintenance of programs is easier and less prone to error. It is economical when compared to the price of buying an optional language such as Pascal. Structured BASIC also provides a good starting point for novice programmers, allowing them to become familiar with the more modern control structures that structured languages provide.

IBM's BASIC
PROGRAMMING DEVELOPMENT SYSTEM

The IBM BASIC Development Programming System consists of four separate tools, packaged neatly with an IBM bookshelf-type manual. The tools are a text file editor for entering BASIC programs into the PC, a preprocessor for converting structured BASIC programs into executable BASIC programs, a formatter for creating more easily read listings, and a utility that provides cross reference information. The manual is separated into several sections that describe the tools and options; a tutorial is included.

The first major section of the manual is a rather short description of the structured "macros" available. (The term "macros" refers to the preprocessor's extensions to the syntax of BASIC, and is somewhat misleading; read "macros" as "keywords" for greater clarity.) These macros provide the means to write BASIC code using statements that provide more conventional structures.

The next section of the manual describes the Text File Editor (TFE), a somewhat more sophisticated and complicated text editor than EDLIN, the line editor supplied with DOS. This tool can be used for general text entry, and is intended as an easy method to allow the construction of a structured BASIC program. The full-screen editor within the BASIC interpreter can also be used. However, the input text for the preprocessor can not contain line numbers so a file prepared in this way must be "unpreprocessed" with a function in TFE called UNPREP. Most other text editors may be used to create a structured BASIC source program.

THE IBM BASIC DEVELOPMENT PROGRAMMING SYSTEM CONSISTS OF FOUR SEPARATE TOOLS, PACKAGED NEATLY WITH AN IBM BOOKSHELF-TYPE MANUAL.

The BASIC Preprocessor is the program that converts the structured BASIC program, written with the available macros, into standard BASIC. The manual description is brief, as the functional description of the preprocessor is quite simple.

The next development tool discussed in the manual is the BASIC Formatter. This is a program that "pretty prints" BASIC programs into a more readable format, by using such techniques as indentation, breaking up multiple statements, and isolating REM statements. This same program is also responsible for generating a cross reference listing. A cross reference tool is extremely valuable when very large programs are under development. Its purpose is to identify where in the program variables are used, where they are modified, and their types (integer or string, for example).

The manual finishes with a chapter describing some preprocessing options, a reference guide to the numerous editing commands available, and various appendices. Topics covered in the appendices include how to convert an existing BASIC binary program to ASCII for use by the preprocessor, how to convert existing programs to structured BASIC (using UNPREP), and how to edit large programs (more on this later).

Definition of Structured Macros

There are several different structured macros available. The first one is a family of IF macros. Using the keywords IF, ENDIF, ELSE, and ELSEIF, several types of IF statements can be constructed. They can become rather difficult to read in a program with many nested IF statements, but they are an improvement over the somewhat limited BASIC IF statement.

The first signs of deficiency in the preprocessor surface with DO macros. The macros available are DO WHILE, DO UNTIL, and COMPLEX DO, all of which define loops. Quite obvious is the omission of the keywords WHILE or UNTIL. These keywords are virtually standard in contemporary programming languages; they will be sorely missed by any well-trained programmer.

ANYONE WITH EXPERIENCE IN USING TEXT EDITORS TO WRITE PROGRAMS WILL MISS THE LACK OF PROPER CURSOR USE, GOOD FUNCTION-KEY-DRIVEN COMMANDS, AND A FULL SCREEN OF PROGRAM STATEMENTS AROUND THE CURRENT CURSOR LOCATION.

For example, structured BASIC's equivalent of a DO WHILE has the following structures:

```
DO ⟨condition⟩
 .
 ⟨statements⟩
 .
ENDDO
```

The usual form of a WHILE loop in most languages is:

```
DO
 .
 ⟨statements⟩
 .
 WHILE or UNTIL
⟨condition⟩
 .
⟨statements⟩
 .
ENDDO
```

In this form, either group of statements may be omitted, and the form is thus consistent for the three common cases: checking the condition first, checking the condition last, or testing in the middle and exiting if the condition is met.

The DO UNTIL type of loop is accomplished this way in structured BASIC:

```
DO
 .
 ⟨statements⟩
 .
ENDDO ⟨condition⟩
```

while the case of exiting in the middle is:

```
DO
 .
 ⟨statements⟩
 .
 LEAVE ⟨condition⟩
 .
 ⟨statements⟩
 .
ENDDO
```

Providing three constructs to do the work of one adds unnecessary complexity to the structured BASIC language and can lead to confusion.

With the SEARCH macro, the BASIC Development System has provided one of the most confusing language constructs ever. In fact, a routine coded with the facility is more confusing than it would be if coded with a combination of a DO and an IF. Not only that, the so-called structure violates the mathematical principles of structured programming; the flowchart provided in the documentation illustrates this clearly.

The SEARCH macro is designed to be used as follows:

```
SEARCH ⟨condition x⟩
  ⟨statements - initial⟩
EXITIF ⟨condition y⟩
  ⟨statements - success⟩
ORELSE
  ⟨statements - loop
   increment⟩
ENDLOOP
  ⟨statements - failure⟩
ENDSRCH
```

This is precisely equivalent to, but less clear than:

```
DO ⟨condition x⟩
  ⟨statements - initial⟩
LEAVE ⟨condition y⟩
  ⟨statements - loop
   increment⟩
ENDDO
IF ⟨condition y⟩ ⟨statements -
    success⟩
ELSE
  ⟨statements - failure⟩
ENDIF
```

IBM's BASIC PROGRAMMING DEVELOPMENT SYSTEM

The purpose of the structure is to allow a repetitive search to be conducted, and to execute one of two statement sequences based on the success or failure of the search. It is an unusual construction, and seems to be of limited value.

(SEARCH seems to be unique to this preprocessor; I know of no other language or preprocessor which provides this facility. -- WF.)

Labels are both necessary and useful. They provide a mechanism for logically defining where to transfer program control. Structured BASIC labels consist of a name prefixed with '@' and ending with a space. This feature eliminates the need to reference line numbers, and thus solves one of BASIC's biggest headaches. Unless very carefully planned in advance, line numbers of subroutines often change in larger BASIC programs, making the development process very difficult.

There are no other macros defined, which is a grave disappointment. If structured software is the goal, why not a PROCEDURE macro? This type of macro, such as

```
PROCEDURE ⟨procedure
                 name⟩
   .
 ⟨statements⟩
   .
END PROC
```

is standard in such structured languages as Pascal, Algol, and PL/1. Procedures can then be assigned meaningful names and called without need for line numbers, as in:

```
CALL ⟨procedure name⟩
```

In summary, the macros are a disappointment. DO macros are implemented poorly, the SEARCH macro is cumbersome, and the lack of a procedure macro is curious. There are some things done correctly, but there are inexpensive packages on the market that include a more conventional and appropriate set of features.

Text File Editor

This is the first program you will use when either attempting to write a BASIC program using the package, or going through the tutorial section of the users manual. This editor seems to have been written for use on a teletype, not a modern personal computer with a sophisticated display and full cursor control.

Major weaknesses of the editor are abundant. When used as a full-screen editor (using the EDIT command), only twenty-five lines of program text can be entered at a time, at which time the cursor goes to the top of the page again. If you do not notice that this happened, or you lose count of the number of lines entered, subsequent lines will overwrite old text lines in replace mode, destroying your program. It is imperative that you save your edits no more than twenty-five lines at a time, and then re-display your program on the screen (because the screen clears when the edit is saved) to see the last line entered, in order

THE BASIC PREPROCESSOR IS THE PROGRAM THAT CONVERTS THE STRUCTURED BASIC PROGRAM, WRITTEN WITH THE AVAILABLE MACROS, INTO STANDARD BASIC.

to continue your work. This problem can be eliminated by avoiding the EDIT command, but of course the program then becomes just a line editor.

The line editor can handle a maximum of 999 lines. Files larger than that can be edited in segments, a process described in one of the manual's appendices.

The basic strengths of a text editor are its ability to quickly insert, search, and change. These features are implemented poorly in this editor, without utilizing the power of a cursor controlled screen and associated function keys. Instead, the function keys are used for DOS support, common BASIC statements, and a HELP command; helpful features, but ones not frequently needed.

An example of the difficulty in using the editor is apparent with the ADD command. The ADD function requires as input the string to be added, a first and last line number that specifies a range of lines that the ADD is performed on, and a "type" designation that specifies that the add is done to either the beginning or end of the line. More usable text editors use the function keys to locate the desired line via search (hit a function key and specify the string, the cursor will be properly positioned, another function key hit will locate the next occurrence of the string) and add (hit a function key and specify a string to add, which is inserted at the current cursor location). The implementation of functions by the IBM text editor requires a substantially higher number of keystrokes than other text editors.

The text editor was the worst part of the package. Anyone with experience in using text editors to write programs will miss the lack of proper cursor use, good function-key-driven commands, and a full screen of program statements around the current cursor location.

Structured BASIC Preprocessor

The objective of the BASIC Preprocessor is to take the edited text program as input and produce a BASIC program that can be executed under the BASIC or BASICA interpreter or compiled by the BASIC compiler. To do this, it expands the structured macros, compresses the source into as few lines as possible to speed up execution time, and converts labels to line numbers.

This program does not have as much user interaction as the text editor does; it simply performs its function. One warning to novices: When the resultant program is executed, error messages are displayed with line numbers created by the preprocessor. There is nothing to directly relate the failure to the text of the structured BASIC program, so you must be prepared to read, study, and debug the compiled version. This, unfortunately, requires some understanding of how the preprocessor compiles the macros into executable BASIC code.

SOME MACROS ARE DONE CORRECTLY, BUT THERE ARE INEXPENSIVE PACKAGES ON THE MARKET THAT INCLUDE A MORE CONVENTIONAL AND APPROPRIATE SET OF FEATURES.

However, this can be alleviated somewhat by using the DEBUG feature of the preprocessor, which expands into BASIC code one statement per line, and will also expand code following two single quotes (''), which the normal preprocessing ignores. This allows debugging statements (PRINTs, data saves, IF statements, etc.) to be included during the testing phase but excluded in the final version of the program.

BASIC Formatter/Cross Reference

The BASIC Formatter "pretty prints" a BASIC program to make it more readable. It separates and indents IFs, loops, and DO statements; indents program statements so that line numbers are readable; breaks multiple statements into single lines; and places blank lines before and after REMarks. This last is useful if there is one REM statement embedded within a group of program statements but is unpleasant to the eye if there is a group of consecutive REM statements. For example, a program with a block of documenting REMarks at the beginning is formatted with two blank lines between each REM statement. The printed result is rather silly.

Curiously, the formatter will not work on structured BASIC text

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files. It only formats *preprocessed* files, or regular BASIC files stored in ASCII. A listing of the structured file can be obtained under control of the editor.

The cross reference is part of the formatter; it is possible to obtain a formatted listing, a cross reference listing, or both. It provides the ability to get a listing of line numbers, variables, or reserved words. Reserved words (the BASIC keywords, like PRINT or INPUT) are specified with templates similar to DOS filename templates. The cross reference program normally does not include the BASIC reserved words.

As is characteristic with this development package, there are better cross reference programs available. The best will print the number of references per line (instead of the line number printed once for each reference), an indicator with line numbers in which the item is modified (extremely valuable if the program doesn't work and you need to find out why the variable doesn't have the right value), and characters that show the variable type (integer, string, array). Also, some other cross reference programs provide flexibility of choice of variable names, allowing, for example, a cross reference to be generated on a single variable name.

Other Features

IBM does not implement the tools it attempted in this package well, and there are functions that are provided in other software packages that are missing. Examples are a trace function (used for debugging), a compress function (used to make the executable BASIC program as small and as fast as possible), and an uncompress function (to make the program usable for the programmer for debug and review). Compress functions result in some major improvements in speed and program size by removing all REM statements, colons, quotes at the end of lines, LET references, and GOTOs when used with ELSE GOTO or THEN GOTO. A compress done on a large program can shrink its memory usage by 30%, with up to a 10% increase in speed. While some compressing is done with the preprocessor in the IBM package, more could be done; some other packages also allow selection of specific compression features.

Could Be Better

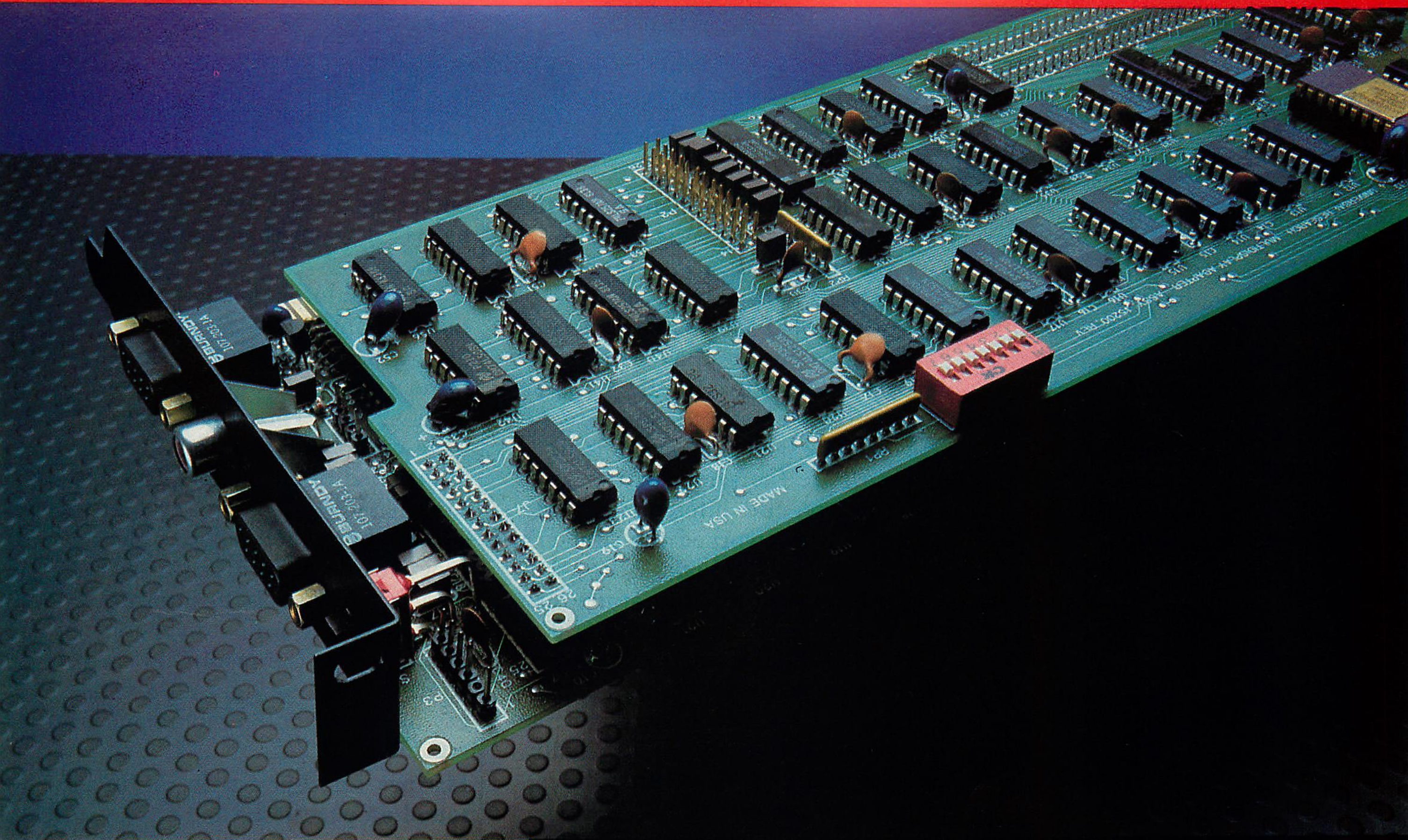
The IBM BASIC Programming Development System could be improved substantially. The text editor was cumbersome and without

IBM DOES NOT IMPLEMENT THE TOOLS IT ATTEMPTED IN THIS PACKAGE WELL, AND THERE ARE FUNCTIONS THAT ARE PROVIDED IN OTHER SOFTWARE PACKAGES THAT ARE MISSING.

flexibility. It required many keystrokes to accomplish simple functions. It is not truly a full-screen editor. There are several better text editors available on the market that are a pleasure to use. The structured BASIC macros defined were barely a subset of those required to write structured programs. The formatter and cross reference programs were not well thought out, and lack many of the functions available in lower priced packages on the market. Even the manual could use improvement; it provided a tutorial chapter and a comprehensive reference to the editing commands (and it was needed due to its complexity), but there was little detail otherwise. Because a novice programmer may be exposed to structured concepts for the first time when using this package, the explanation of how to use the macros was inadequate, and no extensive BASIC program examples were given.

If you are doing a lot of BASIC programming and are looking for a way to do it better by writing programs that are error free and that can be easily changed, a good set of support tools for the BASIC language can be a great help. Do not buy the IBM toolset, however: you are better off surveying the market and buying each piece separately. □

Don Awalt is Applications Software Manager in the Business Systems Division of General Instrument Corporation in Baltimore.



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(continued from page 98)

names may differ from release to release.

For results, see tables 1 and 2.

Using interpreted BASIC as the basis for comparison, some percentages give an indication of the power of the 8087 numeric co-processor. The IBM p-System, which at the time of this writing did not have 8087 support, was 473 percent slower than BASIC. The NCI IV.1 C.0 with 8087 support and native code generation ran in 7.7 percent of the time for the BASIC code. Comparing the two p-System configurations separately, the IBM system is 6,143 percent slower than the optimized NCI set-up. The question is not why the IBM system runs so slowly but why the NCI version is so fast.

THE QUESTION IS NOT WHY THE IBM SYSTEM RUNS SO SLOWLY, BUT WHY THE NCI VERSION IS SO FAST.

The operating systems of both are the same (written by Softech); the difference is that NCI has reworked the time-critical sections of code. All of the real p-codes, such as store, load, add, subtract, multiply and divide, which reside in the interpreter, were rewritten. The REALOPS unit, which supports transcendental functions, is usually shipped with these procedures written in Pascal. NCI's 8087 REALOPS support unit is written in assembler (by Paul Miniato); all the Pascal procedures in the operating system are therefore bypassed when this configuration is used.

Very salutory results are obtained from IBM compiled BASIC, which runs the program faster than most of the other systems shown. Those faster all have one or more of the aforementioned optimizations in their libraries.

As mentioned before, this program is not so much a scientific benchmark as an informative and entertaining diversion. Nonetheless, the results do shed some interesting light on a variety of execution environments.□

Listings for this article are to be found on page 194.

Susan Glinert-Cole, Ph.D., is a staff scientist at Ventrex Laboratories.

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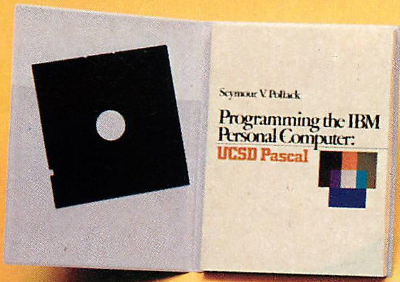

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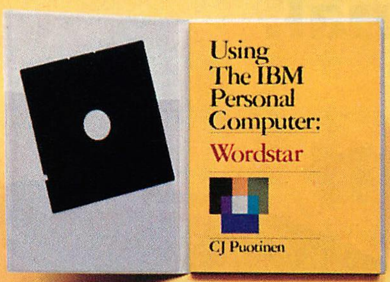

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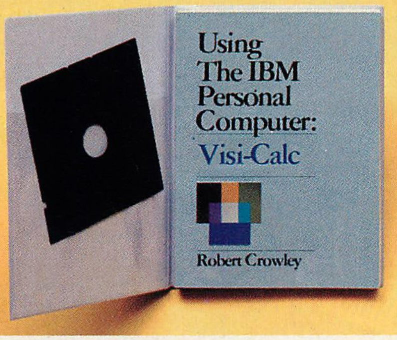

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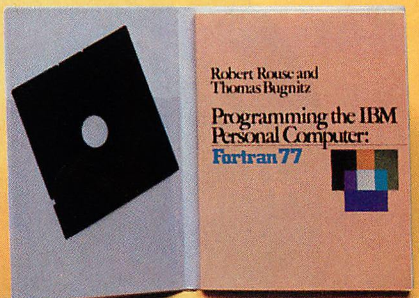

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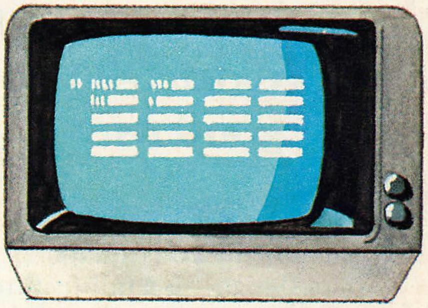

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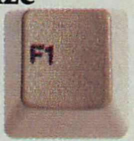

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	Currently own		Plan to buy in next 12 months			Currently own		Plan to buy in next 12 months		
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display character set customization

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The programs described below make it possible to match the characters on the screen to the characters of special printwheels while not otherwise disturbing the operation of the computer. With this utility, when the PC is used for editing foreign language texts or for other special applications, the text will appear on the screen in the same form as in the final printed copy. For example, the "{" key can be made to send "ü" to the screen as well as to the printer. For IBM PC owners who use *WordStar* as their word processing software, who use DOS 1.1 or earlier, and who have more than 64KB of memory, the programs outlined here make it

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(continued from page 121)

possible to adjust the screen image to match any change of character set the user wishes to make—limited only by the inventory of characters in the extended 256 character set provided by PC hardware. (Adjustments in the programs might be required if later versions of DOS, or if different word processing software is used.)

ASCII.COM

ASCII.COM is a screen customizer. The basic idea behind the program is to detour any character that is about to be written to the screen via the ROM video routines, sending it first through a translation table where desired changes can be made before the character appears on the monitor. The system works because, although ROM cannot be programmed, the entry point to ROM video routines is an "interrupt," and interrupts can be accessed directly by software.

It is important to remember that there is no change in the way the keystrokes are actually recorded in *WordStar* text files: a left curly bracket is stored as a left curly bracket, even if the screen displays a "ü" and the printer prints an "ü," because the printer must receive the code number of left curly bracket in order to print the character desired. The utility does not require graphics capability, and is limited to characters in the PC's display character set.

There are two parts to the program: first is the actual customizer, which must remain in place during subsequent text editing; and second is a transient, "initiating" portion, which handles the mechanics of interacting with DOS. This transient portion also makes the customizer operational, by adjusting the default values of interrupt 10, the interrupt for all video routines, so that the progress of a character toward the monitor can be trapped and the desired translation accomplished.

In order to keep the resident portion of the program as short as possible, the translation mechanism is placed at the beginning of the program and the transient portion, which sets up the table, at the end. The outline of the actual program is as follows:

A. The resident portion, which consists of:

1) an instruction to jump to the first instruction of the transient program (100-102);

2) the translation table itself (103-1E2);

3) the instructions that retrieve a new value from the table for each intercepted character (1E3-1F0); and

4) the instructions that "reroute" the translated character back to the video routines in ROM (1F1-1F5).

> *CHARACTERS ABOUT TO BE WRITTEN TO THE SCREEN ARE DETOURED VIA THE ROM VIDEO ROUTINES.*

B. The transient portion, which

1) sets up the stack as required for a .COM program operating under DOS (200-203);

2) moves the contents of INT 10 (which sends characters to the video subroutines of ROM) to INT 50 (20C-217);

3) also moves those contents A4, above (218-225);

4) replaces interrupt 10 with an instruction which sends characters to the translation table (226-230); and

5) returns control to DOS, making sure in the process that part A remains resident (231-235).

Figure 1 contains the program, called ASCII.COM, which accomplishes these tasks. (The particular translation table provided with ASCII.COM does not actually change any of the characters; that task will be discussed later.) ASCII.COM is activated simply by typing "ASCII" while in DOS. Be warned: the system will not work if *WordStar* is already loaded. First load the screen customizer, then load *WordStar*.

NORMAL.COM AND DISPLAY.COM

There are two other programs useful to the full exploitation of this screen customizer: a program to normalize the screen, and a program to display the current screen values of the keys, so that the operator can quickly find the key to strike for whatever special character is desired.

Figure 2 gives the program for normalizing the screen. This program, called NORMAL.COM, is

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similar to the transient portion of ASCII.COM, except that it re-establishes the *original* instructions of interrupt 10, thereby neutralizing the still-resident translation mechanism. To normalize the screen, it is only necessary to type "NORMAL" while in DOS; the effects of any special-purpose screen customizer will be eliminated.

Figure 3 is the program for displaying the character set currently valid on the screen. To activate it, one simply types "DISPLAY" and an upper-case and lower-case character inventory will appear on the screen. This utility makes it possible to find the temporarily-forgotten location of the key that has been given a special character value by the screen customizer; the symbols printed on the keys will no longer necessarily be accurate.

Applications

The original motivation for developing a screen customizer was a desire to better adapt the IBM PC for use as a word processor with foreign language texts. However, there are many other uses for the screen customizer as well. It can be used to disguise what is being written on the screen; it can be used to draw with *WordStar* (by inserting the values of the PC graphics characters into the translation table); all that is necessary is correct programming of the translation table. There are two basic types of application for an adjustable screen.

Customize the screen to make it match the special inventory or arrangement of characters you require. This typically happens when a special printwheel is available. All of the foreign language applications, the OCR-A printwheel, special character sets for matrix printers, etc., belong in this category.

The screen customizer can also be used in less structured ways. For instance, it could be used to prepare coded messages, either for security purposes or for the simple intellectual challenge. If two friends have screen customizers, one could send a garbled message for the other to decipher by figuring out the values of the "secret" translation table.

It is essential that when the screen has been customized, anyone editing a text be aware that the printed characters on the keys will not necessarily match the characters that appear on the screen or with the special printwheel. It is also important that potential users of the file be aware of its special nature.

Also, care must be taken to print files prepared in this way using the matching printwheel on a letter-quality printer or the appropriate character set with a dot-matrix printer.

Customize the screen to make it distinct from the intended use of the keyboard. When work must be done in a public place, or when communication is being received over a modem in a public place, the casual onlooker will see nothing of value if a screen-radicalizing screen customizer is loaded before operation begins.

When a screen customizer is used in this way, the recorded files will be printed exactly as typed, not as shown on the screen. Extra care is therefore necessary in typing, since there is no accurate screen feed-back of what characters are going into the file.

THE SCREEN CUSTOMIZER CAN DISGUISE WHAT IS BEING WRITTEN ON THE SCREEN.

THE CASUAL ONLOOKER WILL SEE NOTHING OF VALUE IF A SCREEN-RADICALIZING SCREEN CUSTOMIZER IS LOADED BEFORE OPERATION BEGINS.

Customizing Ascii.Com

Up to this point, only the mechanism of translation has been developed, but no actual screen customizer. To customize ASCII.COM for a non-ASCII printwheel or character set, it is only necessary to adjust one or more of the numbers in the translation table of Figure 1 (i.e., items 103-17E). Below is a set of step-by-step instructions that will make it possible to prepare a screen customizer for any special purpose, within the limits of the IBM PC character inventory. The instructions to follow will assume that the application involves the use of a special printwheel, although they can generally be applied to any situation.

(continued on page 126)

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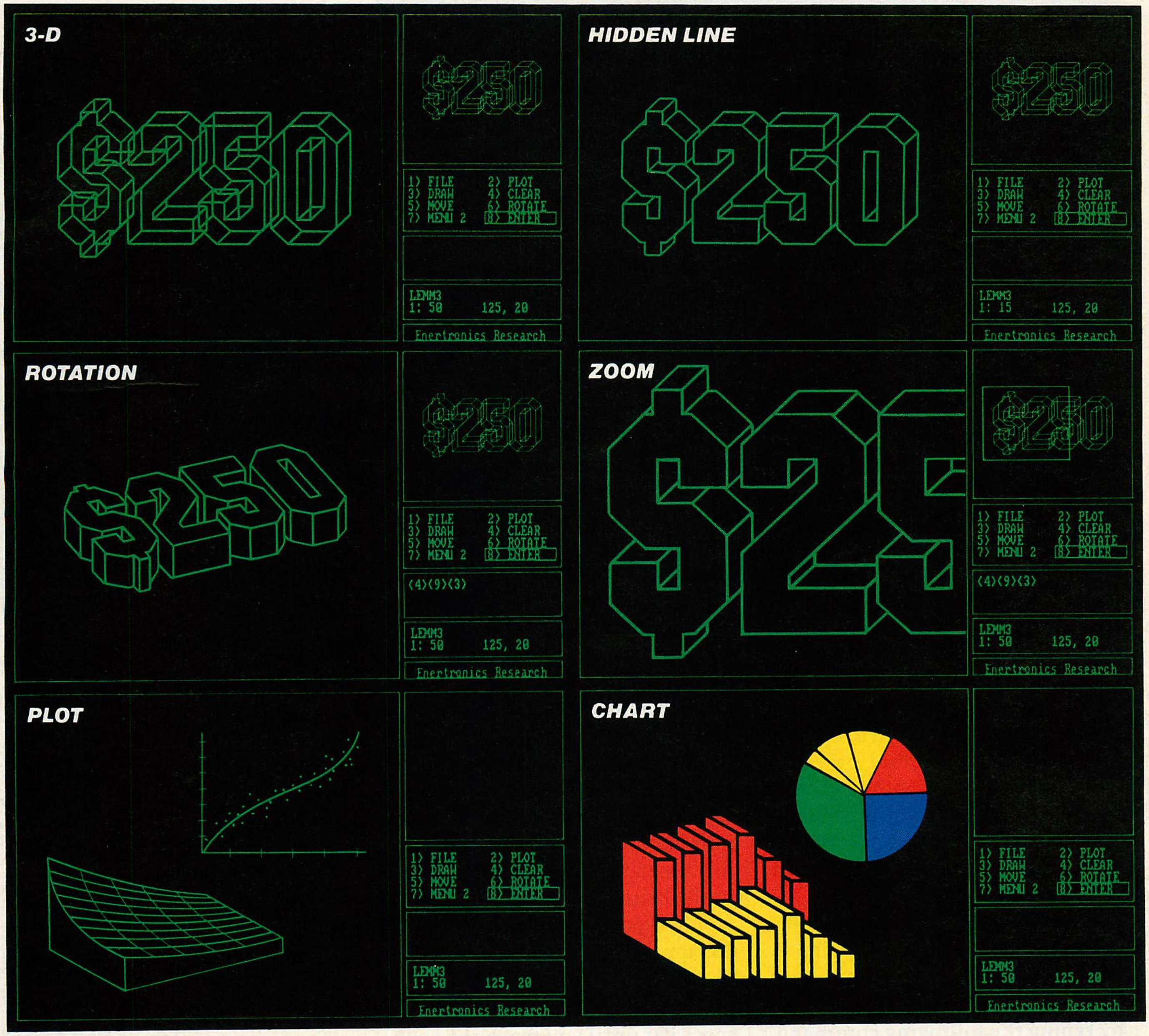

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(continued from page 124)

How To Customize ASCII-.COM for a new Application

1) With a standard, ASCII-sequence printwheel on your printer, run a printer test to obtain a print-out of the ASCII standard sequence of characters.

2) Put the special-use printwheel you are interested in on the printer and run another printer test to obtain a print-out of its special character sequence.

3) Compare the two sets of character sequences and mark all the differences.

4) Make a list of these differences and note the hexadecimal character codes for each pair of differing characters. Arrange the list on the basis of the standard ASCII character codes, arranged in ascending order. Note: The list of characters and character codes in appendix G of the *BASIC* manual for the PC is difficult to use for this purpose, as the code is given in decimal rather than hexadecimal (base 16), the number system of the PC. Also, the chart at the back of appendix C of the *Technical Reference* manual for the PC has some typographical errors; Figure 4 is therefore provided to assist in determining the correct hexadecimal character codes.

5) Make a copy of ASCII.COM by typing the following command (using a name of your own choosing):

COPY ASCII.COM NEW.COM

6) Get the NEW.COM (or DEUTSCH.COM or FRANCE-.COM, etc.) file and the DEBUG-.COM file provided with your operating system software on the same disk, then type:

DEBUG NEW.COM

7) A hyphen prompt will appear, and you are ready to edit; type:

E 103

8) 20: will appear on the screen. Hit the space bar; 21: will appear. Now take out your list of standard character codes and the changes desired. Continue to tap the space bar, watching the number on the screen increase to 22:, 23:, etc., until you reach the code number of the first of the standard characters you wish to replace. For instance, the # character is quite commonly replaced on special printwheels; its code number can be seen from the CHARACTER CODES chart to be 23; to change # to something else, the space bar must be tapped until 23: is showing on the screen.

9) After the number of the character to be altered is on the screen, enter the hexadecimal code number of the new character. For instance, if you wanted to change # to the British pound symbol, you would type 9C when the prompt 23: appeared.

10) If you wish to change more characters, continue tapping the space bar until you reach the code number of the next standard character to be changed, and follow the procedure as above.

SOME CHARACTERS MAY APPEAR IN UNEXPECTED PLACES ON THE DISPLAY KEYBOARD, BUT ONE MUST GET USED TO IT.

11) When all changes have been made, use the W command to write the modified file to disk and the Q command to exit DEBUG.

To try out your new screen, type the name of your new screen customizer to initiate the character set changes, then type DISPLAY to see your characters in their new locations (or, if you know where they are, simply start typing). Some of the characters may appear in unexpected places on the display keyboard, such as an upper case ü on the lower case keyboard, etc.; this is a result of the placement of characters on the printwheels, and one must get used to it.

Deutschland

As an example, a comparison of the standard QUME ASCII printwheel with the QUME DEUTSCHLAND reveals 12 differences. Thus, many standard characters of the ASCII sequence are dropped in favor of special characters essential or at least common in German typewritten material. In the QUME DEUTSCHLAND printwheel, for example, the { is replaced by ü, the } by ä, and so on. The IBM PC has most of these characters in the set of characters numbered from 80 HEX to FF HEX. The list of changes needed to produce a utility capable of creating a DEUTSCHLAND-customized

(continued on page 128)

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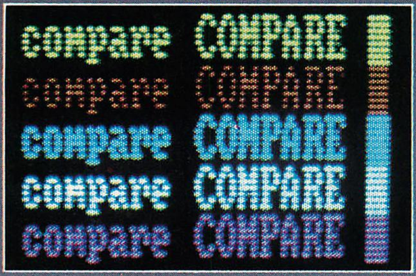
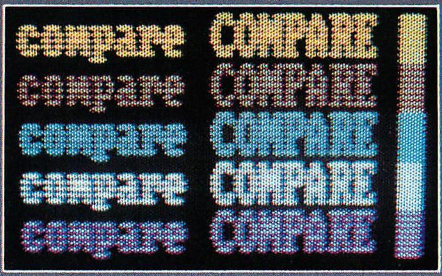


OURS: .31 mm dot pitch, 80 column text.



THEIRS: .43 mm dot pitch, 80 column text.

THE PRINCETON HX-12
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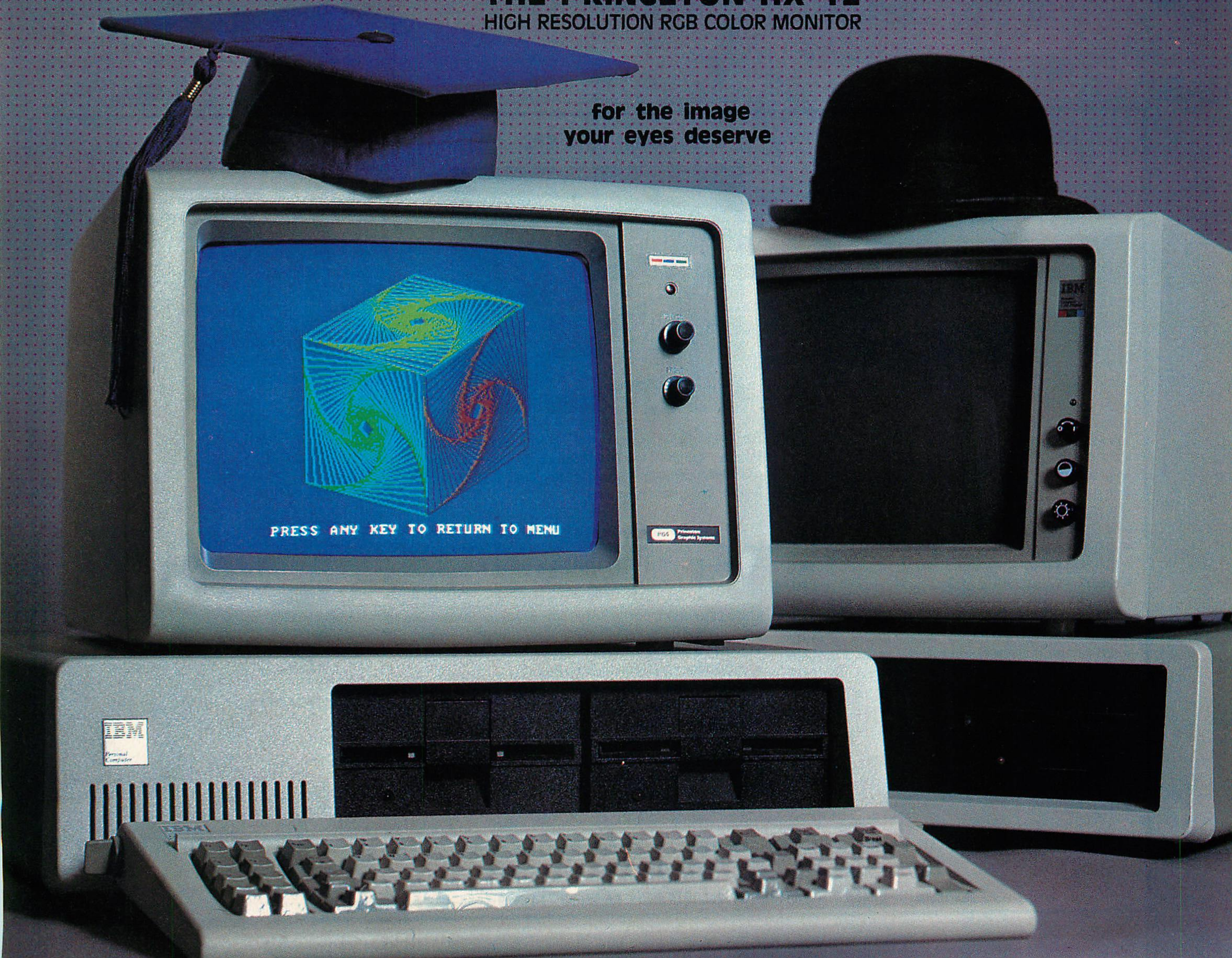


(continued from page 126)

screen is

change	23 to 15	5D to 8E
	3B to FD	5E to 27
	3E to 33	7B to 81
	40 to E1	7C to 94
	5B to 9A	7D to 84
	5C to 99	7E to E6

All of the numbers in this list are in hexadecimal; the number on the left is the original ASCII.COM value; that on the right the replacement value, determined as described above.

Once the screen customizer DEUTSCH.COM has been prepared, it is only necessary to enter the command DEUTSCH at the beginning of an editing session (*before* loading *WordStar*). The disk containing the actual screen customizer can then be set aside. The NORMAL.COM and DISPLAY-.COM files, however, must remain available, most conveniently on the same disk as *WordStar*.

Limits On Screen Customizing

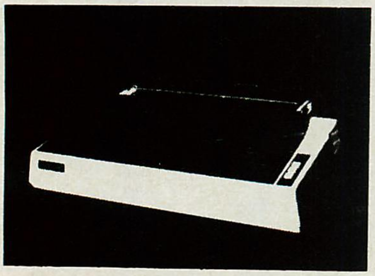
The particular inventory of the PC

THE PC'S CHARACTER SET MAKES IT POSSIBLE TO PREPARE TABLES FOR A GREAT MANY PRINTWHEEL SEQUENCES, AS LONG AS THE ROMAN ALPHABET FORMS THE BASIS FOR THE TARGET LANGUAGE'S WRITING SYSTEM.

character set makes it possible to prepare tables for a great many printwheels, as long as the Roman alphabet forms the basis for the target language's writing system. For example, the QUME wheels MULTI, FRANCE, SVERIGE, DANMARK, SCHWEIZ, NEDERLAND, ESPANA, ITALIA, etc. can be reproduced almost without compromise; other sequences, such as WP, LEGAL, and OCR-A, can each be given a usable screen inventory, although some changes are required. Similar matches are possible with the products of other printwheel producers.

One useful feature of the way in which printwheel manufacturers prepare their wheels is that it is almost always possible to use a foreign printwheel but still type the text in English: the special charac-

EPSON & NEC PRINTERS



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- IDS 80 and 132 PRISM Printers ... CALL
- QUME SPRINT 11/40 and others ... CALL
- ANADEX ADX-9500 and others ... CALL
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- COMREX CR-1 Serial or Parallel ... CALL
- DAISYWRITER 200 w/48K Buffer ... CALL
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- SILVER-REED EXP550-P or EXP550-S ... CALL
- SMITH-CORONA TP-1 and others ... CALL
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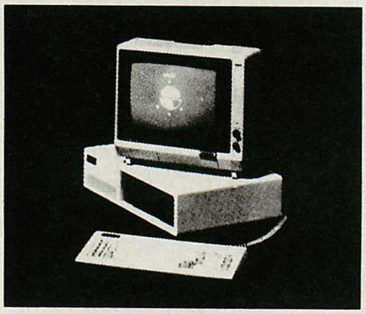
COLUMBIA DATA MPC



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ters are always assigned to little-used keys, like { or #, and never to regular alphabetic characters. Thus, an English text about a French topic can be written normally, but still have the correct accents and characters available for citations in French.

Because the characters are not in the PC inventory, the system described here will not customize the screen for Japanese, Russian, or other non-Roman-based writing systems. Users with special requirements not discussed here can determine for themselves the usefulness of the screen customizer system by inspecting the printwheel or character set they would like to use and comparing it to the character set built into the PC.

The screen customizer will also affect the menus generated by *WordStar*. This can be helpful as a reminder of the customized status of the screen; however, it may interfere with your ability to read the menus and messages if the translation table has been edited radically.

QUME SEQUENCES MULTI, FRANCE, SVERIGE, DANMARK, SCHWEIZ, NEDERLAND, ESPANA, ITALIA CAN BE PRODUCED ALMOST WITHOUT COMPROMISE.

Final Comment

Although the implementation of a screen customizer for the PC may be new, many PC users will find the concepts discussed here fairly basic. However, for the humanities scholar working in Medieval French or Old English, this is probably not the case. Therefore, a copy of the three programs described here will be provided to those sending a 5¼" DD disk and a stamped return mailer to the address shown at the end of the article. Comments on applications, compatibility, problems, etc. are also invited. □

Figures accompanying this article to be found on pages 196, 199.

Daniel Brink is a Professor of English at Arizona State University. His mailing address is Department of English, Arizona State University, Tempe, AZ 85287.

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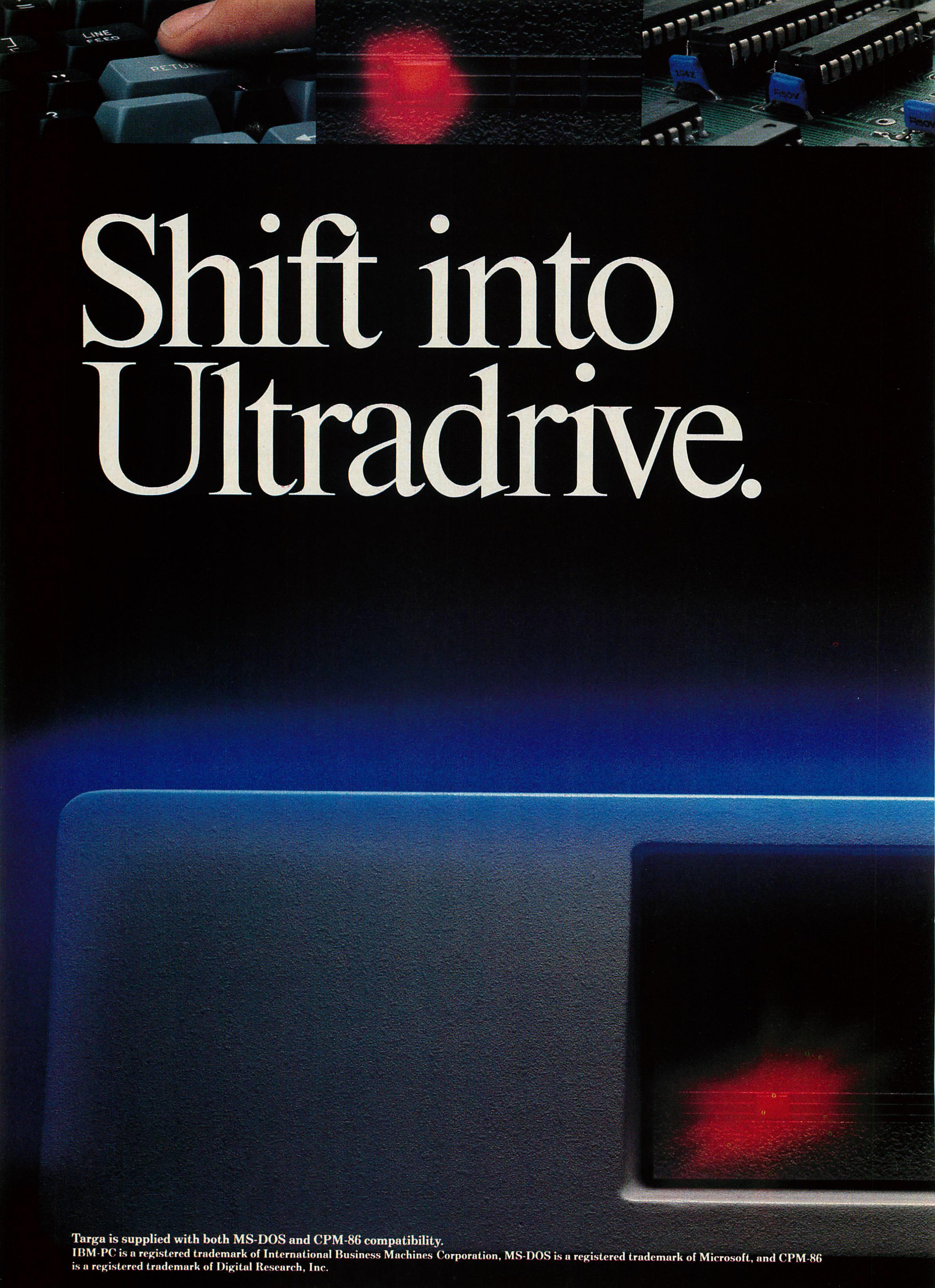
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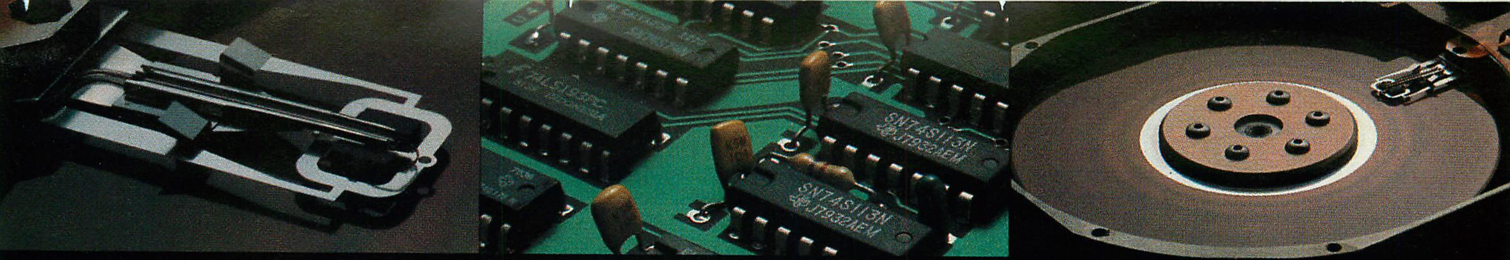

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TECH NEWS

(continued from page 23)

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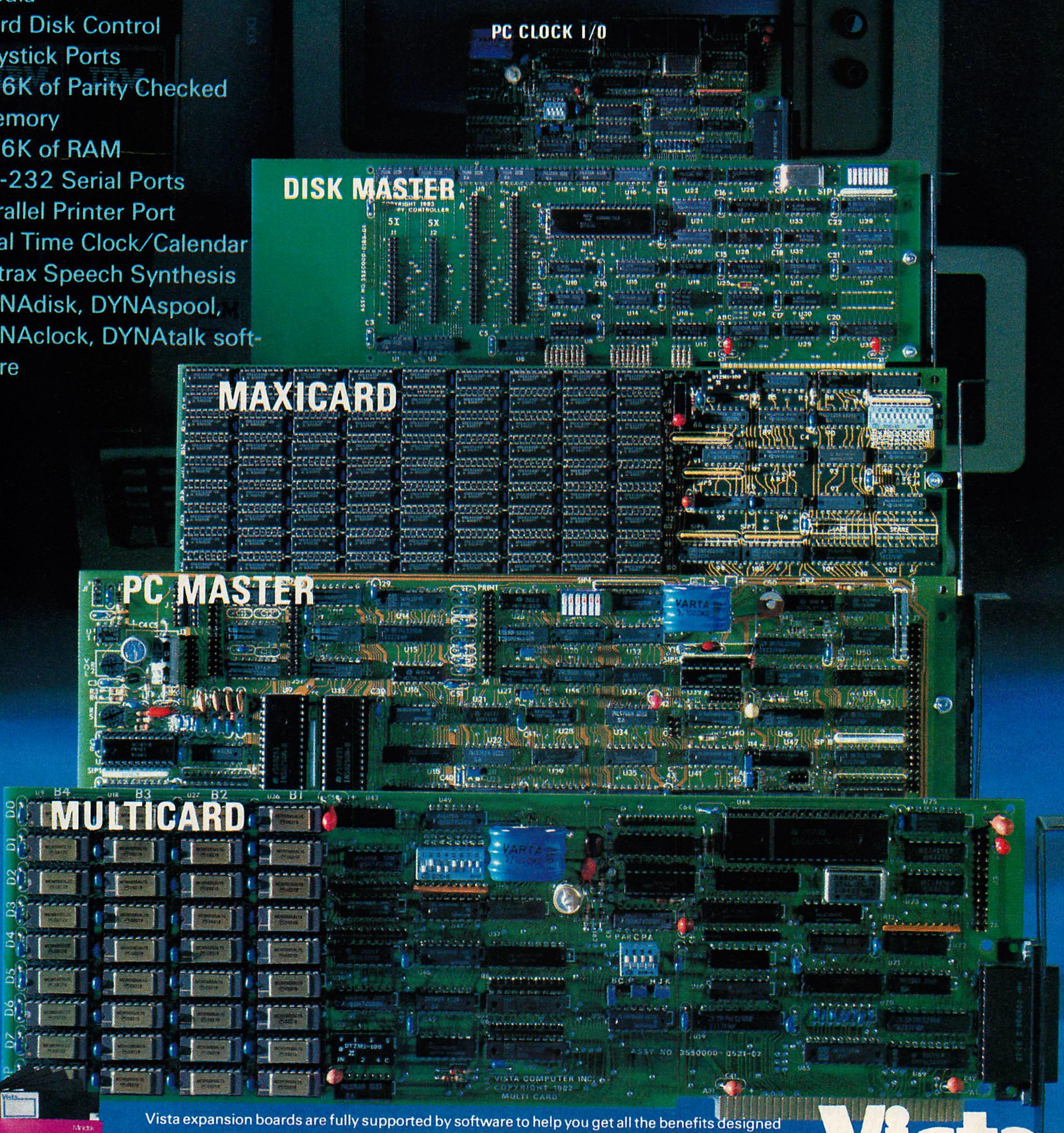

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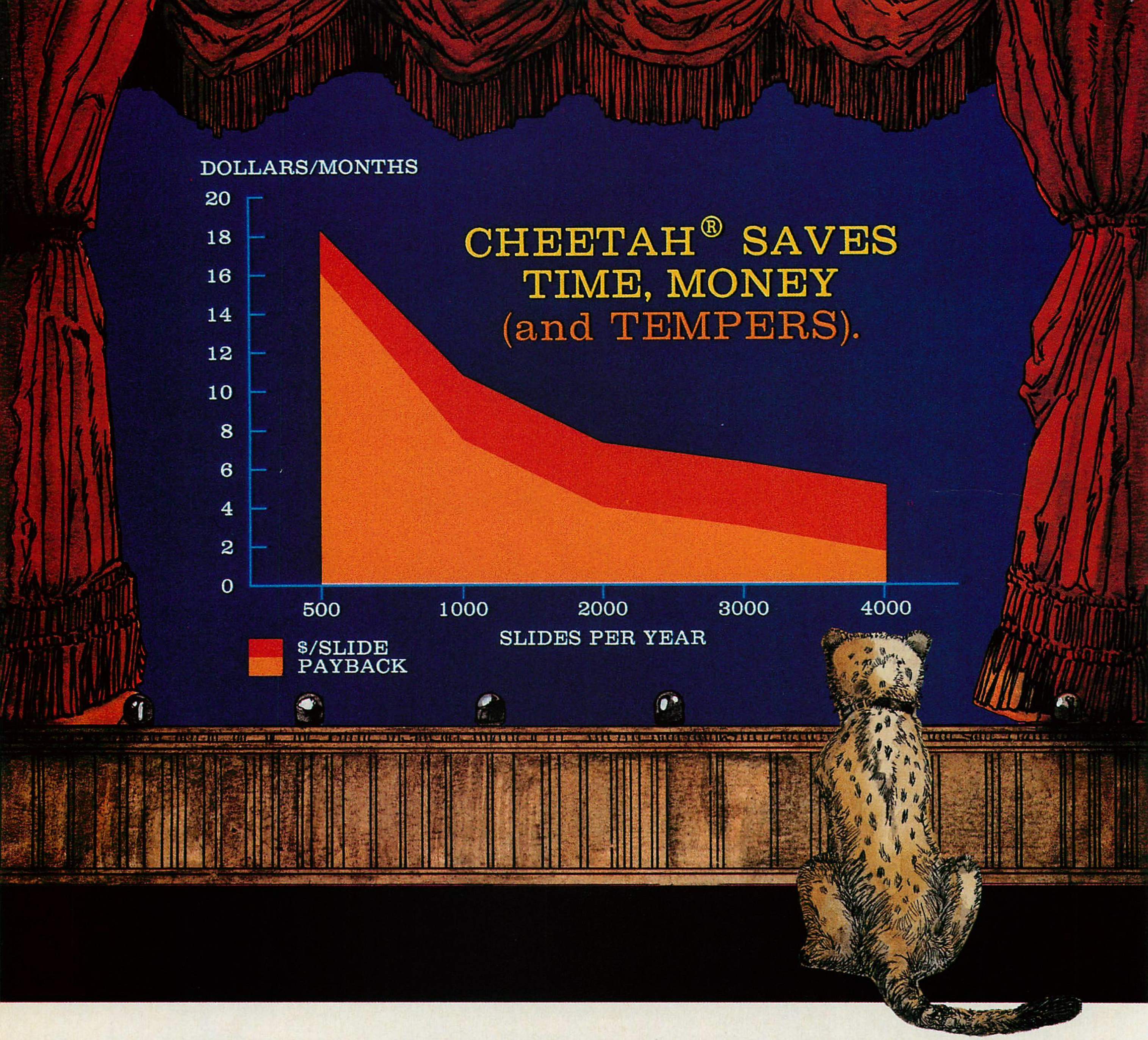

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(continued from page 46)

Color with High Resolution Graphics

Remember that in 640 by 200 graphics, each pixel is represented by a single bit in the display buffer. Each pixel has two states, '0' and '1', which ordinarily display as black and white, respectively. The horizontal resolution of most composite displays is many fewer than 640 dots, in fact it's closer to 300. This means that two adjacent pixels in 640 dot mode will appear as a single brighter dot rather than as two distinct dots.

With the color burst enabled (mode bit 2 set to '0'), a composite color monitor or receiver will interpret portions of the high frequency video signal as color information, giving rise to "artifact" or "false" colors. Groups of four adjacent pixels can be treated as one large pixel with 16 possible color values. These artifact colors are not the same as the 16 "true" IRGB colors (see photograph 1). The artifact colors formed by each of the 16 four-bit values, aligned on half-byte boundaries, are shown in photograph 2.

The qualifications mentioned above are two: this is not really *high resolution* color, because only 160 effective pixels are possible per line, and it only works on composite monitors or TV sets. Even so, the results are quite pleasing and very simple to achieve, even from BASIC.

The first step is to enable the color burst signal, by setting mode register bit 2 to '0'. In BASIC this should be possible with a SCREEN 2,0 statement, but it isn't; BASIC ignores the color burst parameter for high resolution mode. The manual even states that "since black and white are the only colors in high resolution graphics (mode = 2), this parameter will not have much effect." The parameter may have no effect, but the colors are just over the rainbow. Enter the following little BASIC program, RUN it, then LIST it.

```
10 '-- Set Up High Resolution
       Graphics
15 '-- With 16 Colors
20 MODESAVE = &H465
25 MODEREG = &H3D8
30 BWENABLE = &H04
35 DEF SEG = 0
40 SCREEN 2,0 '-- Set High Res
      Graphics
45 MODE=PEEK(MODE-SAVE)
      AND NOT BWENABLE
50 POKE MODESAVE, MODE
55 OUT MODEREG, MODE
```

Table 7 — 6845 Register Values for Standard Modes
(All values are in decimal)

	Register	Units	R/W	40×25 Alpha	80×25 Alpha	320/640×200 Graphics
00	Horizontal Total	Char	W	56	113	56
01	Horizontal Displayed	Char	W	40	80	40
02	Horiz. Sync Position	Char	W	45	90	45
03	Horiz. Sync Width	Char	W	10	10	10
04	Vertical Total	Char Row	W	31	31	127
05	Vert. Total Adjust	Scan Line	W	6	6	6
06	Vertical Displayed	Char Row	W	25	25	100
07	Vert. Sync Position	Char Row	W	28	28	112
08	Interlace Mode	---	W	2	2	2
09	Max Scan Line Addr.	Scan Line	W	7	7	1
10	Cursor Start	Scan Line	W	6	6	6
11	Cursor End	Scan Line	W	7	7	7
12	Start Addr. (High)	---	W	0	0	0
13	Start Addr. (Low)	---	W	0	0	0
14	Cursor Addr. (High)	---	R/W	--	--	--
15	Cursor Addr. (Low)	---	R/W	--	--	--
16	Light Pen (High)	---	R	--	--	--
17	Light Pen (Low)	---	R	--	--	--

EACH PIXEL HAS TWO STATES, '0' AND '1', WHICH ORDINARILY DISPLAY AS BLACK AND WHITE.

Table 8 — 6845 Register Values for Alpha-Graphics

(All values are in decimal)

	Register	Units	R/W	40×50 80×50	80×50 160×50	80×100 160×100
00	Horizontal Total	Char	W	56	113	113
01	Horizontal Displayed	Char	W	40	80	80
02	Horiz. Sync Position	Char	W	45	90	90
03	Horiz. Sync Width	Char	W	10	10	10
04	Vertical Total	Char Row	W	63	63	127
05	Vert. Total Adjust	Scan Line	W	6	6	6
06	Vertical Displayed	Char Row	W	50	50	100
07	Vert. Sync Position	Char Row	W	56	56	112
08	Interlace Mode	---	W	2	2	2
09	Max Scan Line Addr.	Scan Line	W	3	3	1
10	Cursor Start	Scan Line	W	32	32	32
11	Cursor End	Scan Line	W	0	0	0
12	Start Addr. (High)	---	W	0	0	0
13	Start Addr. (Low)	---	W	0	0	0
14	Cursor Addr. (High)	---	R/W	--	--	--
15	Cursor Addr. (Low)	---	R/W	--	--	--
16	Light Pen (High)	---	R	--	--	--
17	Light Pen (Low)	---	R/W	--	--	--

Notes:

1. Standard widths (40 and 80) use character code &H20 (blandk) to fill entire 8×N pixel character block. Double widths (80 and 160) use character codes &HDE or &HDD to have independent control over foreground and background 4×N pixel blocks.

2. R10 is set to 32 to disable cursor display.

SOME BASIC KNOWLEDGE OF THE WAY TELEVISION IMAGES ARE FORMED ON THE SCREEN IS NECESSARY TO FULLY UNDERSTAND THE OPERATION OF THE DISPLAY ADAPTER.

Those hard to read, irridescent characters are the first evidence of artifact colors. To see them under more controlled conditions, we can fill a portion of the screen with one of the 16 color patterns and see a uniform patch of color. The most direct method is to POKE right into the display buffer.

```
100 '-- Fill Upper Left Corner
        of 640x200 Screen
110 '-- With 80x20 Color Block
120 DEF SEG = &HB800
130 LOCATE 23,1: INPUT
        "COLOR: ",C
140 C = C AND &HF
150 CC = C * &H10 + C
160 FOR SCANLINEPAIR
        = 0 TO 9
170 EVENLINEADDRESS =
        SCANLINEPAIR * 80
180 ODDLINEADDRESS =
        EVENLINEADDRESS
        + &H2000
190 FOR BYTEOFFSET = 0
        TO 9
200 POKE EVENLINEAD-
        DRESS + BYTEOFF-
        SET, CC
210 POKE ODDLINEAD-
        DRESS + BYTEOFFSET,
        CC
220 NEXT BYTEOFFSET
230 NEXT SCANLINE
240 GOTO 130
```

Lines 140 and 150 take the input color number, mask it to 4 bits, and replicate it into both halves — or *nibbles* — of the byte. The loop at line 160 runs for ten pairs of scan lines, first calculating the starting address in the display buffer for the even and odd members of the current pair. In 640 dot graphics, 80 bytes of 8 pixels each make up one scan line, and odd lines are displaced by exactly half the buffer from their even counterparts. The inner loop at line 190 stores 10 bytes of the pattern into each line. The exact colors will vary from display to display and can be adjusted with the hue or tint control on the set.

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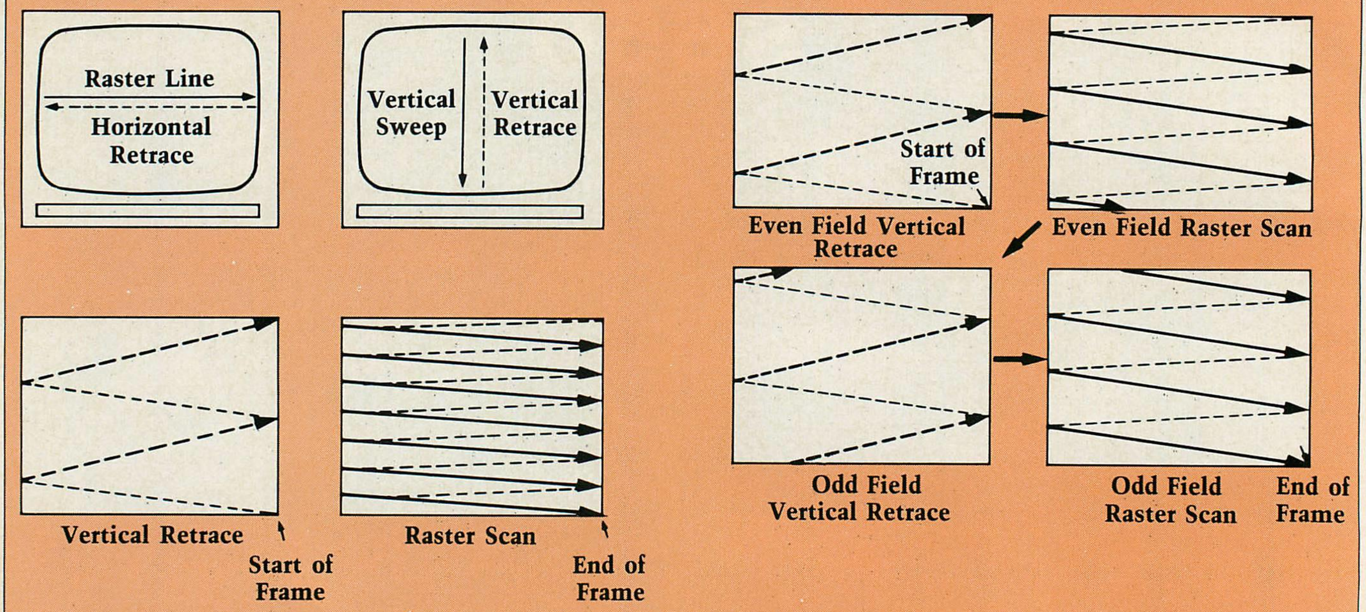
Figure 4: Raster Scanning Patterns



A. The independent horizontal and vertical sweeps of the elector beam generate a regular raster pattern when they are snychronized by the CRT timing circuits.

B. When alternate fields are delayed by half the horizontal time interval, an interlaced raster pattern results.

Another method for filling a rectangular area with a color pattern uses the LINE statement to draw vertical lines in adjacent columns, skipping columns where the color code has a '0' bit. This is somewhat faster than POKEing, and allows us to deal in pixel coordinates rather than buffer addresses, a welcome simplification that avoids the messy business of interleaving scan lines. The following subroutine assumes a coordinate system of 160x200 and fills a block specified by its upper left and lower right corners.

THE COLOR RESULTS ARE QUITE PLEASING AND VERY SIMPLE TO ACHIEVE, EVEN FROM BASIC.

```
1000 '-- Fill Block (x1,y1)-
         (x2,y2) with color C
1010 FOR X = X1 TO X2
1020 X4 = X * 4 '--Trans-
         form X to 640 Coords
1030 CMASK = 8
1040 FOR I = 0 TO 3
1050 IF (CMASK AND C)
         = 0 THEN 1080
1060 XC = X4 + I
1070 LINE (XC,Y1)-
         (XC,Y2)
1080 CMASK =
         CMASK / 2
1090   NEXT I
1100 NEXT X
1110 RETURN
```

The program "BOXES" (page 183) displays randomly positioned boxes drawn in high resolution graphics, then PAINTS them with a color pattern using the BASIC 2.0 extension for tiling an area with a repeating pattern. This is much simpler and faster than either of the previous two methods, but requires BASICA version 2.0. A typical display is shown in photograph 3. It might be fun to try variations using circles or arbitrary polygons.

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Some basic knowledge of the way television images are formed on the screen is necessary to fully understand the operation of the display adapter, and especially the role of the 6845 CRT controller.

The image never really exists all at once on the screen. What you see is the illuminated trail left by a continuously moving electron beam which repeatedly traces a rectangular pattern of regularly spaced horizontal lines, called a *raster*. As the beam moves, its intensity at the instant it passes a point determines the brightness of the picture at that point. Color displays have three beams that move together, but have independently controlled intensities, one for each of the primary colors red, green, and blue.

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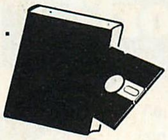

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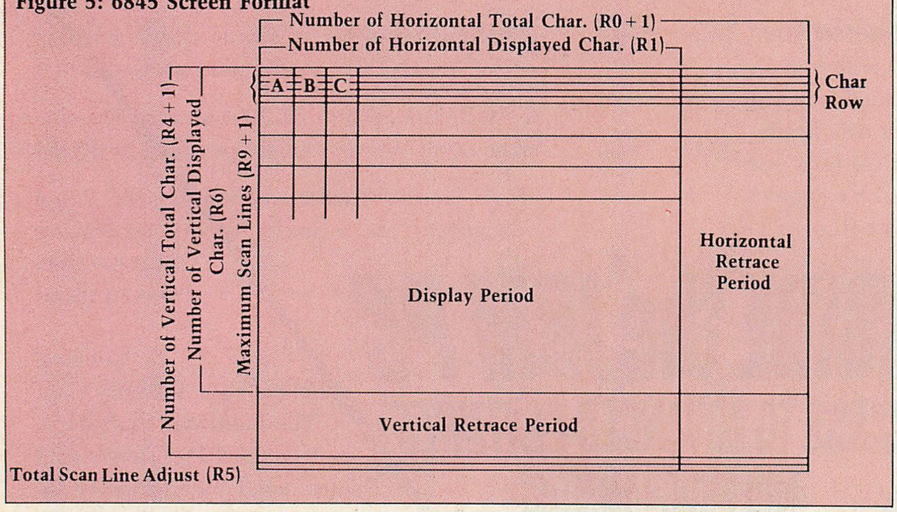
Figure 5: 6845 Screen Format



A horizontal deflection circuit in the monitor sweeps the beam from the left edge of the screen to the right, then more quickly back to the left. The rightward motion traces a *scan line*, and the leftward return is called the *horizontal retrace*. A similar, but independent, vertical deflection circuit sweeps the beam from the top edge to the bottom and back again. The downward motion is called *vertical sweep*, and the upward return is the *vertical retrace*. When the horizontal and vertical sweeps occur simultaneously and are synchronized, the beam traces a raster on the screen. The scan lines are tilted downward to the right due to the vertical sweep. Figure 4 illustrates these various scanning patterns.

The time from the end of one horizontal or vertical sweep to the end of the next, including the associated retrace, is called the *H-interval* or *V-interval*, respectively. Monitors are designed so that the V-interval is an exact multiple of the H-interval. This makes it possible for the electron beam to start in the lower right corner of the screen, zig-zag its way to the top right corner for the start of another scan of the entire raster, and end up in the lower right corner again to repeat the cycle.

The display adapter must synchronize the horizontal and vertical deflections with each other and the information to be displayed. This is done by means of horizontal and vertical sync pulses, which define the start of the respective retraces, and the video signal, which defines the display intensity and color.

The rate at which the video information changes determines the number of dots, or pixels (picture elements), per scan line. The color graphics adapter operates at a dot rate of either 14.31818 MHz or 7.15909 MHz. Standard U.S. television monitors and receivers make 15,750 complete horizontal scans per second, giving a scan line time of 63.49 microseconds. At the 14 MHz rate that gives 909 potential dots per line, but only 640 are displayed. The remaining time is allocated to the screen border and horizontal retrace interval.

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Vertical timing is calculated in a similar fashion. A complete vertical scan, including retrace, occurs 60 times per second. Dividing the V-interval by the H-interval gives 262.5 lines per vertical sweep. In normal broadcast television, the extra half line causes the beam to begin every other downward pass at the center of the screen instead of the upper left corner, tracing a path exactly between the scan lines of the previous pass. This is called interlace and results in a complete 525 line frame 30 times per second, each composed of successive even and odd fields of 262.5 lines each.

The color graphics adapter normally operates in non-interlaced mode, with identical 262-line fields scanned 60 times per second. This gives a steadier image by sacrificing vertical resolution for more frequent refresh. Only 200 lines are used to display the image, with the other 62 devoted to border and vertical retrace.

Motorola 6845 CRT Controller

The 6845 CRT controller coordinates the access to the display buffer with the horizontal and vertical timing of the display monitor. The controller is fed by the basic 7 or 14MHz dot clock, which is used to generate sets of output signals: video timing control, consisting of horizontal and vertical sync and a display enable signal; 13 memory address lines, used to address up to 8K pairs of bytes in display buffer; and three row lines used to address the character generator ROM. In graphics modes the low order row address line is used as the highest order refresh memory address line. This causes even and odd scan lines to be fetched respectively from the lower and upper halves of the display buffer.

Types of Displays

The color graphics adapter supports two types of display devices: direct drive monitors and composite monitors, including television receivers used with an RF modulator. Either type of display may be monochrome or color.

Direct drive monitors have separate vertical sync, horizontal sync, and video inputs. Monochrome monitors have a single video signal. Direct drive color monitors, often called RGB monitors, have three video inputs, one for each of the red, green, and blue electron guns. If these inputs are digital (they are independently on or off, with no intermediate values) the monitor can display eight colors. Some digital RGB monitors have a fourth input signal that controls the intensity of all three guns, allowing them to display 16 colors. In analog RGB monitors the intensity of the beam is proportional to the voltage applied to the video inputs. These monitors are much more expensive than digital monitors but have the advantage of being able to display a practically infinite number of colors. The IBM Color Graphics Adapter only generates binary RGB and intensity signals, so it cannot take advantage of the capabilities of analog color monitors. They can still be used, however, with proper signal level converts.

Composite monitors accept a combined signal that contains both sync and video information. They are generally less expensive and have poorer resolution than direct drive monitors.

Television receivers are essentially composite monitors that extract the composite video signal from a modulated radio frequency (RF) carrier. Because the CGA generates only unmodulated, or baseband, composite video, an external RF modulator is required to produce the television frequency signal required by a receiver.

Despite their poorer picture quality, composite monitors and TV sets have several advantages over direct drive monitors. The first is price. Even with the added cost of the RF modulator — about \$30 to \$70 — televisions are the least expensive displays available for the IBM PC. Composite monitors are only slightly more expensive, and of much better quality than standard TV sets. A related advantage is multiple use. It's a lot easier to convince your spouse to let you buy another TV than it is to watch the 11 o'clock news on an RGB display. Composite monitors can also be used with video cassette recorders and disk players. Finally, only composite color displays can be used to get multiple colors in 640x200 high resolution color mode, such as the Microsoft Flight Simulator, look much worse on expensive direct drive monitors than on cheap black and white TV sets. On RGB displays, this technique produces coarse black and white images instead of uniformly colored ones.

The card has two connectors on the rear panel for attaching display monitors, and another on the card itself. A fourth connector, a 6-pin Berg strip near the rear of the card, is for a light pen. The round RCA phono jack on the rear bracket (just like the ones on the back of your stereo) is for a composite video monitor. The same composite video output is available on a 4-pin Berg strip connector on the card for attaching an RF modulator. The 9-pin D shell connector on the rear bracket is for a direct drive RGB monitor, and carries the separate red, green, blue, intensity, horizontal and vertical sync signals.

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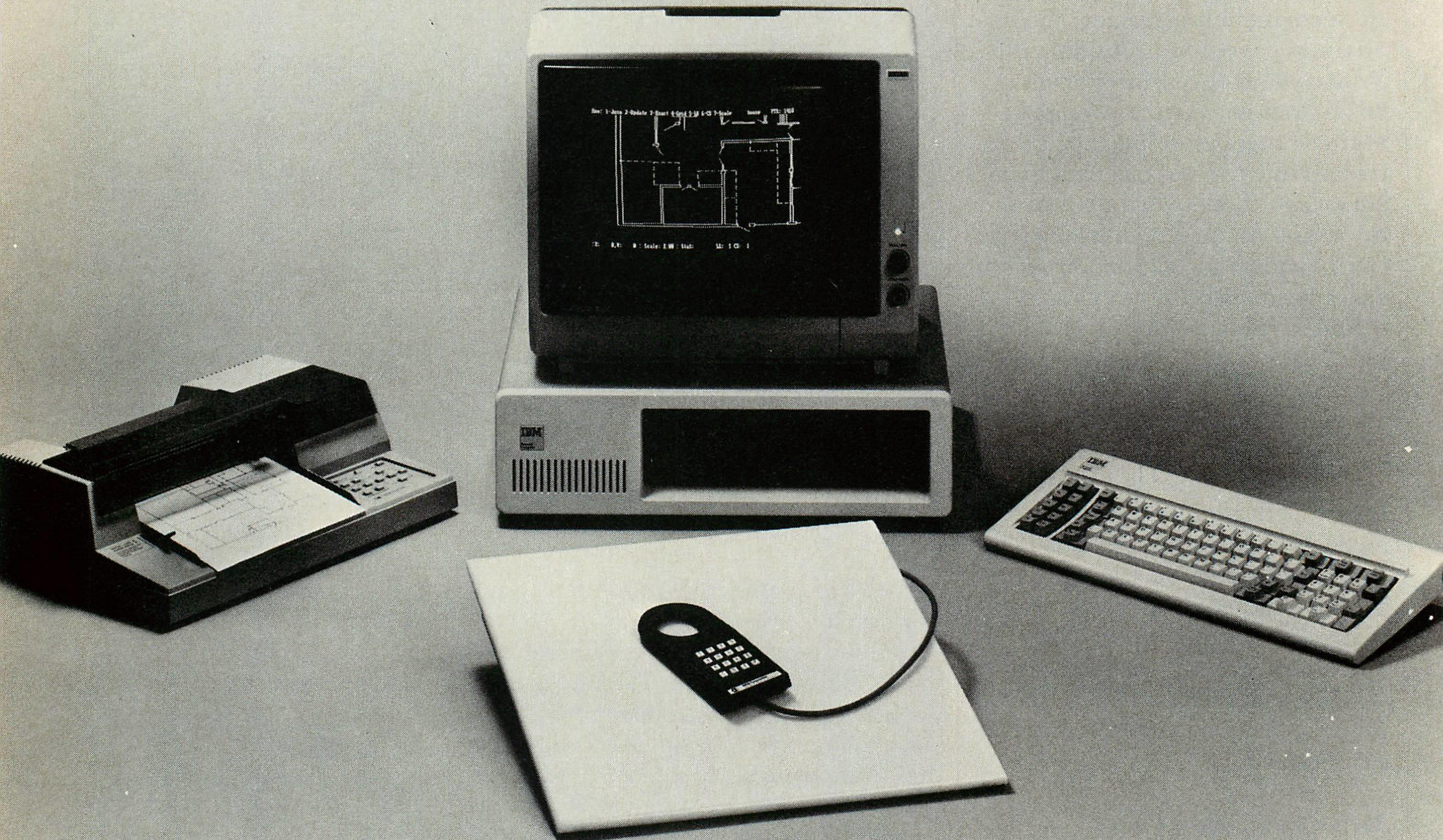

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The 6845 has 18 internal data registers that can be programmed to handle a variety of display formats. These registers are accessed by writing the data register number to the 6845's Address Register at I/O address &H3D4, then reading or writing the desired value at I/O address &H3D5.

Table 6 summarizes the 18 data registers. Table 7 shows the initial register values for the standard alpha and graphics modes.

6845 Register Descriptions

The first 10 registers define the character and screen formats. These values must be set to generate the proper timing intervals for the monitor used. The video timing is programmable in terms of character times, which are always eight dot times for the horizontal dimension and vary depending on the programmed number of scan lines per character for the vertical dimension. Figure 5 shows the CRT screen format as viewed by the 6845.

Standard U.S. television monitors have a horizontal interval of 63.5 microseconds, and a vertical interval of 1/60 second or 16,667 microseconds. The following discussion uses the 40 by 25 alpha mode as an example, with characters composed of 8 scan lines of 8 dots each, and a dot clock rate of 7.15909 MHz. This gives a dot time of 139.7 nanoseconds and a character time of 1.12 microseconds.

THE 6845 HAS 18 INTERNAL DATA REGISTERS THAT CAN BE PROGRAMMED TO HANDLE A VARIETY OF DISPLAY FORMATS.

Horizontal Timing Registers (R0 through R3)

Horizontal Total (R0)

This 8-bit register determines the frequency of the horizontal sync pulse, which should closely match the duration of the horizontal interval. It is programmed to the total number of character times minus one. (H-interval / CharTime = 63.5 / 1.12 = 57 - 1 = 56 Chars)

Horizontal Displayed (R1)

This 8-bit register is programmed to the number of characters displayed per horizontal line.

Horizontal Sync Position (R2)

This 8-bit register is programmed to the character position at which the horizontal sync pulse should occur. This should be approximately five microseconds after the last displayed character. A smaller value places the sync pulse closer to the last displayed character, thus moving the image to the right. Similarly, a larger value moves the image to the left. This is how the DOS MODE command adjusts the horizontal position of the display.

Horizontal Sync Width (R3)

This is a 4-bit register which determines the width of the horizontal sync pulse.

Vertical Timing Registers (R4 to R9)

Vertical Total (R4) and Vertical Total Adjust (R5)

These registers determine the frequency of the vertical sync pulse, which should match the duration of the vertical interval (1/60 second). The integer part of the calcu-

(continued on page 163)

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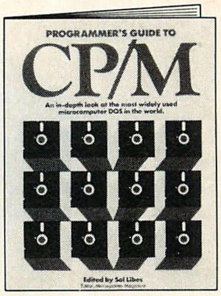

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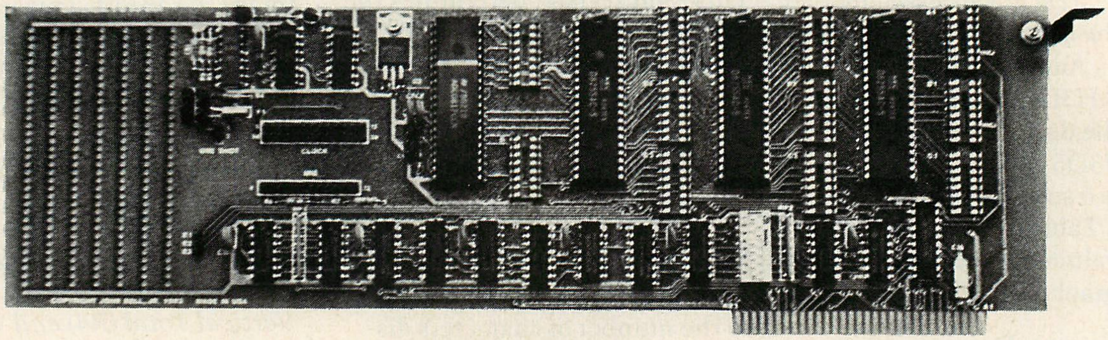

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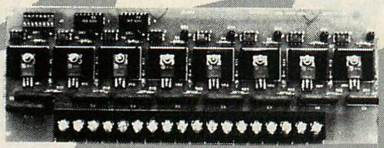

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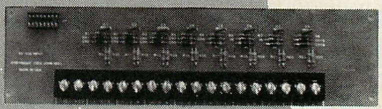

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Automatic Screen Dumps from BASIC

WILL FASTIE

A PROGRAM FRAGMENT WITH TWO SUBROUTINES THAT CAUSES AUTOMATIC SCREEN DUMPS UNDER PROGRAM CONTROL.

Just about everybody knows how to get a copy of the screen printed at the printer: you just press the PrtSc key, shifted. Graphics images can be dumped in the same way with DOS 2.0. When BASIC is running, however, the PrtSc key is not recognized under certain conditions. Furthermore, it may be desirable to cause the screen to be dumped automatically under program control.

The program below (see Listing 1) is a fragment that does just that. It is not a program that will run by itself: the fragment contains two subroutines that can be called by any BASIC program.

The first subroutine POKEs a machine language routine into a safe spot in memory. The code for this routine was assembled by the DOS 2.0 debugger (see Listing 2), but it will work in previous versions of DOS as well. The purpose of the machine code is the issue interrupt 5, which is the way the print screen routine is invoked. Note that the routine uses the RETF instruction; this is necessary because the BASIC CALL statement issues FAR calls. The safe memory location in this case is at the bottom of the third 64K bank of memory (i.e., above the 128K boundary), and thus out of the way of BASIC. If there is less than 128K of memory, the choice of a segment address must be different. This subroutine must be called only once.

The second subroutine is called when a dump of the screen is desired. Note that this routine issues a DEF SEG statement to be sure the call will succeed. If DEF SEG is used elsewhere in a program using these routines, this routine should be changed to restore the desired segment address after the CALL to SDUMP. This subroutine may be called as often as desired.

The IBM print screen routines dump the image from the display device currently selected.

THE FIRST SUBROUTINE POKES A MACHINE LANGUAGE INTO A SAFE SPOT IN MEMORY.

Listing 1

```
40000 ' Setup Screendump Routine in Memory
40010 DEF SEG = &H2000:  SDUMP = 0
40020 RESTORE 40090
40030 READ N
40040 FOR I = 1 TO N
40050   READ X
40060   POKE I-1, X
40070 NEXT I
40080 RETURN
40090 DATA 7
40100 DATA &h55
40110 DATA &h89, &he5
40120 DATA &hcd, &h05
40130 DATA &h5d
40140 DATA &hcb
40200 ' Call the Screendump Routine
40210 DEF SEG = &H2000:  SDUMP = 0
40220 CALL SDUMP
40230 RETURN
```

Listing 2

```
2000:0000 55        PUSH   BP
2000:0001 89E5      MOV    BP,SP
2000:0003 CD05      INT    05
2000:0005 5D        POP    BP
2000:0006 CB        RETF
```

On systems with both displays installed, therefore, the programmer must be sure that the displays are switched accordingly. Of the commercially available screen dump programs that are invoked with the PrtSc key, some only dump from the color display regardless of the display setting. □


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3. If you follow the instructions in the manual, you will get the promised results; if not, IBM will either fix the program or the manual or at least give you a refund.

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SHOULD YOU BUY AN IBM SOFTWARE PACKAGE? IF THE ANSWER TURNS ON LEGAL REMEDIES, PROBABLY NOT.

Figure 1 — IBM Agreement

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Figure 2

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The legal issues are fascinating, but few people want software for the thrill of the legal issues presented by the transaction. The average purchaser simply wants a working package of hardware and software which, when used according to the manual, will produce predictable results. The challenge then is to restructure the licensing agreement or neutralize its purported effect.

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(continued on page 154)

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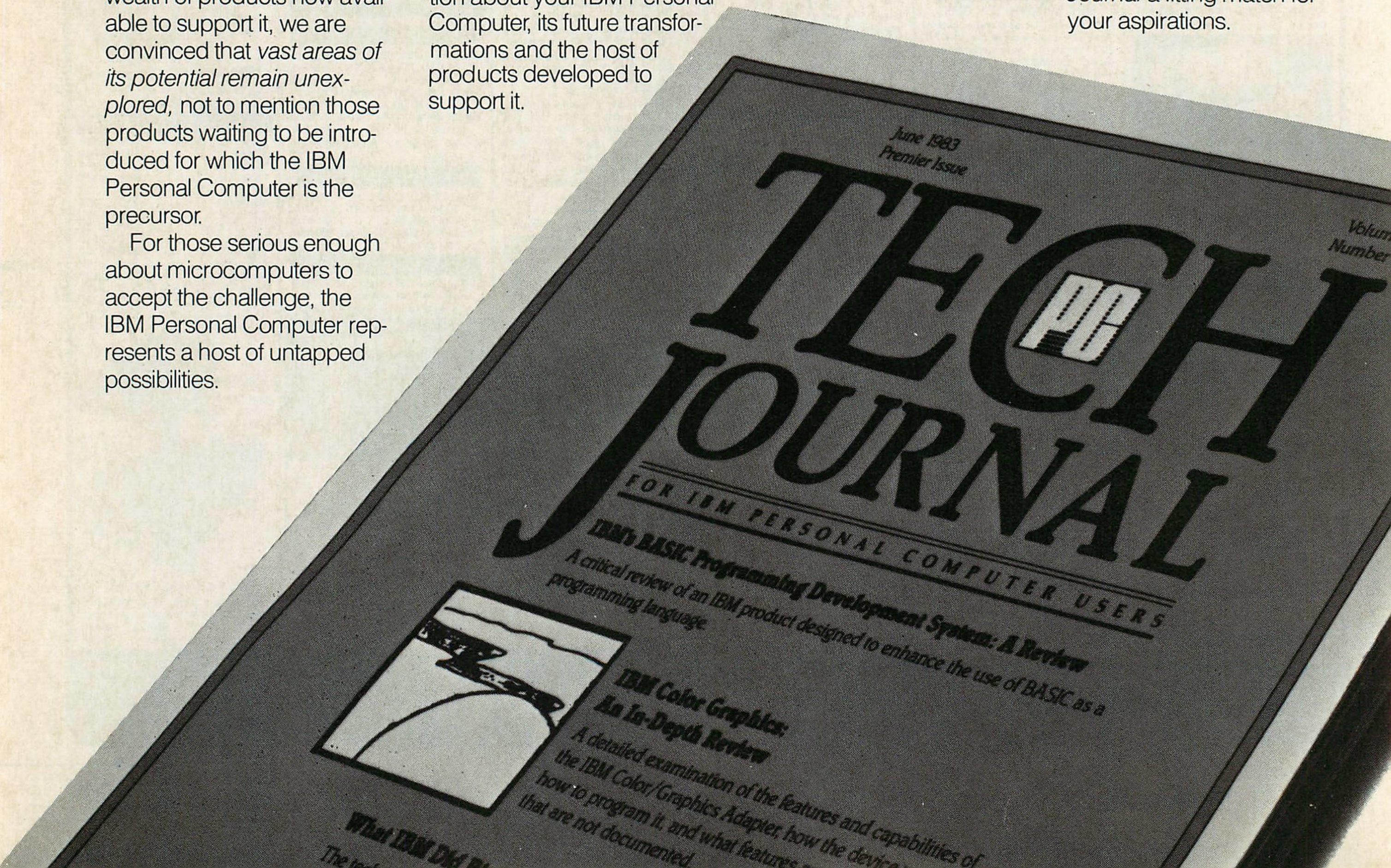

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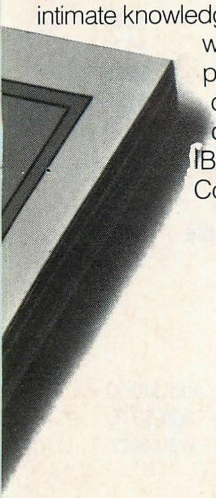

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OPPENHEIMER: SOFTWARE

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Max Stul Oppenheimer is a partner in the firm of Venable, Baetjer and Howard in Baltimore, Maryland. Curiously, he owns an Apple II+ computer system.

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while" is almost identical, but it inverts the exit test by enclosing the XB While test in "NOT (...)".

"Proc endrep" pops both generated labels off the stack, generates a BASIC GOTO statement to the "jump back" target label, then places the "jump out" target label on the statement which will immediately follow the GOTO in the generated BASIC program.

Processing of XB "If" statements is similar to that of Repeat statements, and won't be elaborated.

"Do" statements are processed, in effect, by changing the "Do" keyword to GOSUB and changing the procedure name to the appropriate BASIC line number. "Procedure" statements associate names with BASIC line numbers, and "Endproc" statements are turned into RETURN statements.

The Generated BASIC Program

XB produces an ugly, hard-to-read BASIC program. Each string of blanks and tabs in the XB source program is compressed into a single blank in the BASIC output. Control logic is very difficult to follow because many of the transfers of control in the BASIC program are made via the jump vector at the end of the program. It's impossible to look at a GOTO statement generated, for example, as part of an "If" statement, and tell where it's going without consulting the vector at the end of the program. XB's only concession to the readability of the BASIC program is its identification of the first lines of procedures by BASIC comments giving their names.

THE XB PRECOMPILER BROUGHT ME FACE TO FACE WITH ALL THE THINGS THAT WERE WRONG WITH BASIC, ALL THE REASONS I WAS WRITING XB.

An ugly output program is not necessarily a drawback to XB. After all, the whole point of compilers is to isolate programmers from the complexities of the target language. Programmers write code in the high-level language which accomplishes their goals, and the compiler does the scutwork of arranging to get the job done in the low-level language.

In practical terms, though, there is one good reason for wanting a readable object program. Since compilation takes a relatively long time, it is often desirable to fix, or "patch", an object program to correct a minor error so that testing can proceed and yield more information which should be taken into consideration the next time the program is edited and compiled. XB object programs are a little harder to patch than typical assembly language programs because their jump vectors obscure transfers of control.

A BASIC object program creates an environment in which it's more tempting to patch a program because of BASIC's good support for interactive program testing and modification. Using XB effectively requires the discipline either to patch sparingly and recompile often or to record the XB equivalents of BASIC patches in the original XB program assiduously.

(continued on page 161)

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(continued from page 159)

CONCLUSIONS — THE BAD NEWS The obvious drawback of XB is that it removes programmers from the comfortable, highly interactive BASIC program development environment. No longer can programs be modified or corrected and tested immediately, without waiting for a compiler to retranslate them after changes. Purists may argue that truly professional programmers don't need the luxury of "online" program changes and direct execution of statements, but in practice the BASIC fast-turnaround environment affords a lot of advantages.

The XB compiler's processing of syntax errors is *terrible.* In many cases, if the compiler encounters a construction it can't process (a programming mistake or typo) it quits. No production compiler worth its salt would require programmers to agonize through the discovery of their errors one by one, running the compiler further and further into the source program each time until all the syntax errors had been found and corrected. In order to make practical use of the XB compiler as it stands, a programmer must take meticulous care to use correct syntax, and must proofread extensively if he is to avoid many time-consuming partial compilations which are terminated early by errors.

The XB compiler is *slow.* On a good run under interpretive BASIC,

XB PRODUCES AN UGLY, HARD-TO-READ BASIC PROGRAM—THAT'S NOT NECESSARILY A DRAWBACK TO XB.

(continued on page 190)

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(continued from page 145)

lated number of character line times minus one is programmed into R4, and the remainder in scan lines is programmed into R5. This allows the vertical sync timing to be quite precise, and eliminates vertical rolling of the image.

(V-interval / CharLineTime = 16667 / (8 * 63.5) = 32.81 char lines)

(R4 = 32 - 1 = 31, R5 = 8 * .81 = 6.48 = 6 scan lines)

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Vertical Sync Position (R7)

This 7-bit register determines the position of the vertical sync pulse with respect to the first displayed row. The nominal value is about 1524 microseconds past the last displayed character row and is programmed in character row times. Smaller values will lower the displayed image; larger values will raise it.

Interlace Mode (R8)

This 2-bit register controls the raster scan pattern. A value of 0 or 2 selects normal, or non-interlaced mode. In this mode, each field traces the same raster on every vertical sweep. In interlaced modes, the vertical sync position of every other vertical sweep is offset by 1/2 of the H-interval time, resulting in two alternating sets of interlaced scan lines (see figure 4). A value of 2 selects interlaced sync mode, where each field displays the same information. The effect is to fill in the spaces between scan lines, which can make characters appear more solid. A value of 3 interlaces both the sync and video signals, displaying even lines in the even field, and odd lines in the odd field. This effectively doubles the vertical resolution of the display. Both interlace modes have the disadvantage of increased image flicker, since the image is refreshed at half the non-interlaced rate. For interlaced operation, the horizontal total character count must be even (R0 must be odd). For mode 3 only, there must be an even number of displayed character rows (R6) with an even number of scan lines in each (R9 must be odd), and the cursor start and end registers must both be even or both be odd.

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Maximum Scan Line Address (R9)

This 5-bit register determines the number of scan lines per character row, including blank lines for spacing between rows. It is programmed to one fewer than the number of odd scan lines in each row.

Other Registers

Cursor Start (R10) and End (R11)

These registers determine the format of the cursor in the character block. Bit 6 of R10 is intended to enable cursor blinking, but the color adapter has its own external blinking logic. When bit 6 is '0', a '1' in bit 5 disables the cursor display, and a '0' enables the cursor. Bits 0-4 of R10 set the cursor start scan line, and the 5 bit register R11 sets the cursor end scan line.

Start Address (R12, R13)

This 14 bit register determines the address in the refresh buffer from which the first character of the frame is fetched. The upper 6 bits are written to R12 and the lower 8 bits to R13. These registers should

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be programmed to the number of character/attribute byte pairs from &HB800:0 to be skipped. The actual refresh memory adress for the beginning of a frame will always be even.

Light Pen Register (R16, R17)
This 14-bit read-only register is used to store the current refresh memory address when the light pen input signal goes high. The registers are in the same format as R12 and R13, and indicate the number of byte pairs from the beginning of &HB800:0.

Cursor Register (R14, R15)
This 14-bit register stores the cursor location in the same refresh address format as R12 and R13. It may be read or written.

PROGRAMMING THE 6845 FOR ALPHA-GRAPICS
The 6845 always treats the display as an array of characters, whether the adapter is in alpha or graphics mode. The standard IBM graphics modes are set up as 100 rows of 40 characters each, with each character row being two scan lines high. This gives the 200 line vertical resolution. The same external logic that fetches two bytes per character column from the display buffer in alpha modes is also used in graphics modes, but the video information is formed directly from the pixel information in the buffer rather than from the character generator.

A variety of low resolution, 16 color graphics modes can be programmed with the adapter's alpha mode by changing the character dimensions of the screen. The technique uses the character code &HDE, which has a pattern of four columns of background and four of foreground. By filling every character code position with &HDE, the two nibbles of each attribute byte can be used to individually set any one of the 16 IRGB colors in each pixel. The maximum horizontal resolution in this method is 160—80 characters with two halves each. The vertical resolution can vary from 25 rows of 8 scan lines each, to 100 rows each two scan lines high.

Table 8 shows the 6845 parameters for several alpha-graphics formats. The program "KSCOPE" (page 183) uses this technique in 160x100 to generate kaleidescopic patterns, with four axes of symmetry. Obviously, there are countless variations.

The color adaptor has a problem with color in high resolution alpha mode on composite monitors or TV sets which require a bit of special handling. The Technical Reference Manual indirectly aludes to this when it says that alphanumeric mode can display up to 25 rows of 40 characters for color TVs and up to 25 rows of 80 characters on direct drive monitors. Color in 80 columns attempted in the normal fashion works fine on RGB displays but looks quite monochromatic on a TV set.

The problem is apparently caused by the way the adaptor generates the color reference information in the composite video signal. It can be overcome by setting the border color to yellow ('1110' in bits

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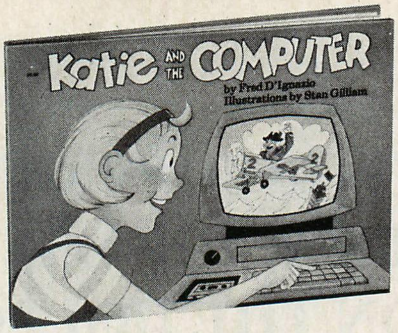

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COLOR

0-3 of the color select register) and adjusting the brightness and contrast controls on the set. It's still hard to read text, but the display will decode the color signals more or less correctly, which is just what we need for the alphagraphics technique described above. The only drawback is that the border will be yellow. This can be done in BASIC with

```
COLOR ,,14
```

where the third parameter is the border color. Other settings also give interesting results: setting the border to blue (1) still gives a yellow border, but complements each color in the displayed area — red, green, and blue become cyan, magenta and yellow respectively.

In the accompanying example program KSCOPE, change line 1380 to

```
1380 POKE COLORSAVE,14:
OUT COLORREG,14
```

for operation on composite monitors or TV sets.

Conclusion

The color adapter is a very versatile device, capable of much more than the standard IBM modes support. The information and techniques presented here should provide a good foundation for further experiments in the realm of the clever, or just a better appreciation of the ordinary. After all, there's no place like home. □

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1. IBM Personal Computer Technical Reference, IBM Corporation, P.O. Box 1328, Boca Raton, Florida 33432.
2. Motorola MC6845 Advance Information AD1-465, Motorola Semiconductors, 3501 Ed Bluestein Blvd., Austin, Texas 78721.
3. Raster Graphics Handbook, Conrac Division, Conrac Corporation, 600 North Rimsdale Avenue, Covina, California 91722.

Thomas V. Hoffmann is Director of Advanced Systems Development for General Instrument Corporation and an expert in computer graphics.

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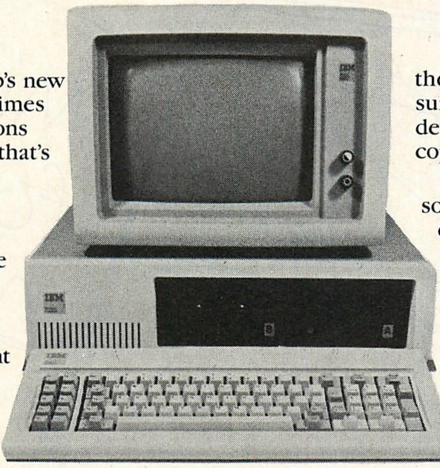

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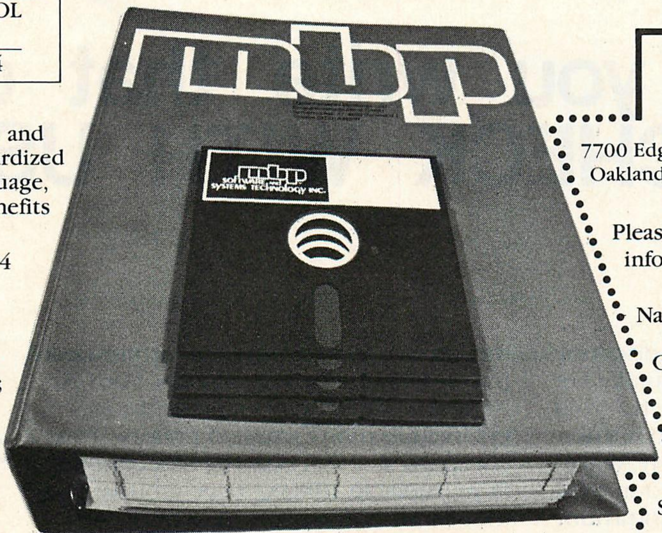

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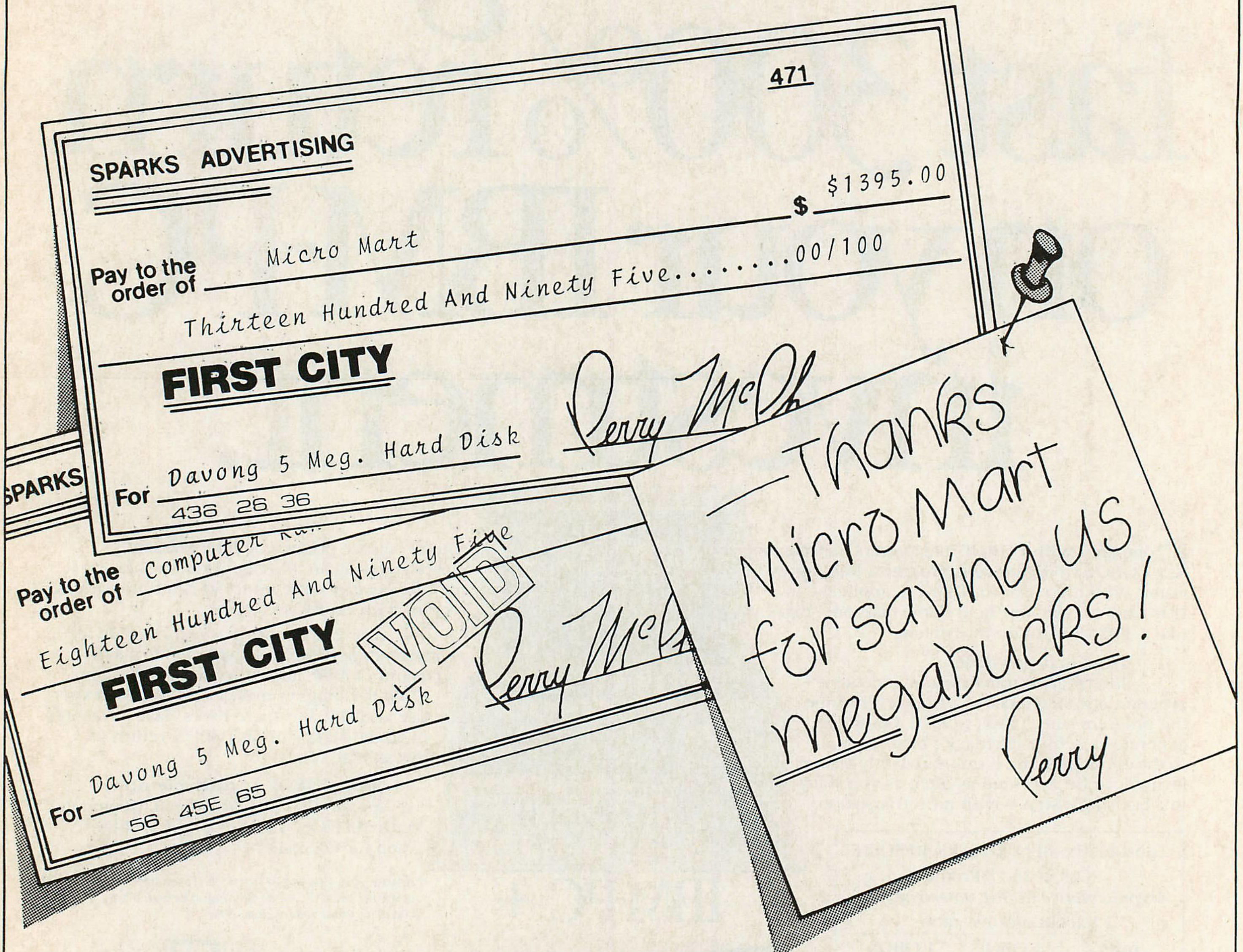

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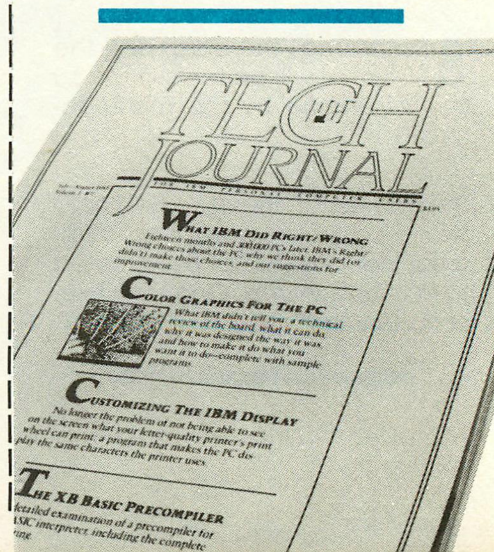

(continued from page 56)

IBM decided to begin so modestly. Clearly, sales of the system were not particularly hampered, although it is a certainty that they could have been higher with bigger disks. It is also hard to find a reason for the initial high cost: the price of the drives was outrageous. And now, with drive capacities of up to 360KB, IBM still lags a bit behind and charges high prices.

It is possible that IBM was, once again, simply being cautious. The first revision of DOS was notorious for its slowness of disk operation, and until DOS 1.1 came out to improve that situation, many vendors offered speedup software, sometimes as part of their hardware products. The slowness was due to a timing delay, an excellent example of conservative design. IBM operated the disks well inside their specification, with a very comfortable margin. That same margin was simply narrowed a bit to achieve the new, improved performance.

IBM has pioneered a number of disk innovations during their long history. It is a pity that none of it shows in the PC. We can only hope that we will not have to suffer through numerous releases of the operating system every time IBM wishes to increase the capacity of the diskettes by 40KB.

Display Adapters

Although we have mentioned the displays, we have not mentioned the adapters that control them.

The Color/Graphics Adapter is described in painstaking detail elsewhere in this magazine. Here we offer only a few observations. Given the mandate to provide the broadest possible support for display devices, including TV sets, IBM did a credible design job. Like the diskette adapter, it is very much driven by software. As a result, the device can handle composite and RGB displays in a variety of resolutions and colors.

The Monochrome Display and Printer Adapter supports only the IBM monochrome display or equivalent, and offers neither color nor graphics. It does, however, offer text operation in a way consistent with the operation of the Color/Graphics adapter. Although having two display technologies to choose from is a nuisance, IBM deserves credit for making them compatible for non-graphic programs.

Unfortunately, they also deserve criticism for failing to provide an excellent feature on both devices. The color board, with its 16KB of memory, can hold four full pages of text. One page is the "active" page and is displayed on the screen. The other pages can be manipulated (read and written) without disturbing the displayed text; a program can instantly switch the display between these pages. This feature is not available on the monochrome board, which with 4KB of memory supports only one display page. Very few programs take advantage of this feature of the color board since to do so is to prohibit operation of the program on the monochrome board.

IBM HAS PIONEERED A NUMBER OF DISK INNOVATIONS. IT IS A PITY THAT NONE OF IT SHOWS IN THE PC.

One way to have improved upon this situation would have been to allow the mapping of the video memory to any block of physical memory. Although this is difficult because both the 8088 and the Motorola 6845 have certain speed requirements, it would have provided the ability to use some advanced display techniques, including animation.

A second failing of both display adapters is their slowness. Speed of display can be increased by placing character codes directly in the video memory, but this generates interference which causes snow. The interference can be avoided through the use of the provided IBM firmware, although display speed is then reduced to a point at which characters cannot be displayed quickly enough to keep up with their receipt over a 9600 baud communications line. The slowness of the displays masks the inherent power of the PC and is an irritant in many programs.

Finally, neither display incor-

THE DISPLAY GENERATION TECHNOLOGY LEAVES SOMETHING TO BE DESIRED.

(continued on page 170)

(continued from page 169)

porates any custom VLSI (very large scale integration) circuits. To be sure, there are few anywhere in the design of the PC, but the display adapters have a considerable amount of simple circuitry surrounding the 6845 chip. This is logic that could have easily been integrated into a number of "packages," IBM's unique multi-circuit chip carriers. An obvious advantage of packages is the board space they save. Then, perhaps, both display technologies could have been placed on a single board. The cost would have been lower, and our decision about which display adapter to purchase could have been eliminated.

The display generation technology leaves something to be desired. Unfortunately, IBM is either stuck with these decisions for the sake of compatibility, or we are stuck with soon-to-be-obsolete machines when they announce the next, great, *different* PC!

Software

One of the reasons for the existence of *PC Tech Journal* and other IBM magazines is the complexity of the software issue. And just as certainly, we cannot hope to explore it in detail in the remainder of one article. However, there are a few points worth mentioning.

First and foremost, the IBM PC with 64KB of main memory and DOS 1.1 is a *very* formidable machine. In addition to the 64KB of RAM the machine contains 8KB of basic I/O software and 32KB of BASIC interpreter, as well as whatever video memory is present. It is appalling that so little software, especially the more complicated systems programs like language compilers, fits in such a system. For years software vendors have jammed code into limited Z80 address spaces and delivered quite functional programs. Yet the PC, with all its built-in support, seems small at 64KB.

The built-in support is quite good, too. The firmware, known as "ROM BIOS," is true to PC values with its conservative design. However, it is very complete and extraordinarily flexible; any part that does not suit can be excised in favor of an improved version, or just a favorite way of doing things. The BIOS supports almost all the devices at various levels of sophistication, forming the foundation upon which more complex programs can be developed.

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sign of BIOS that it can even be removed. It resides in a single 8KB ROM, which can be replaced with a ROM containing completely different software. Although it has not often been used in this way, the PC is worth considering as the basis for a proprietary hardware engine, one which contains not the standard IBM firmware but a unique program designed for a particular task. A systems designer has the liberty of optimizing those things most important to the task (like making the display run faster) and extending areas for which IBM has provided limited support (like the asynchronous adapter routines).

Strangely enough, considering the size and complexity of the computer as a whole, the PC's firmware may be its best-engineered part.

Also resident in ROM is a very complete implementation of Microsoft BASIC. Although this was a good choice on the part of IBM, it is unfortunate that the interpreter does not perform as well as might be expected. Most critics have assumed that Microsoft's 8080 version was simply translated to the 8088, and that it does not take advantage of the power of the bigger processor. It is also possible that the *architecture* of the interpreter was carried across, even if the code was completely rewritten. The Microsoft BASIC interpreter is one of those programs that has been highly optimized for the 8080 and Z80 market; such optimization is not simply using the proper instruction at the proper place, but also designing the system in a way that fully exploits the processor. Whatever the case, the performance of the PC running BASIC should be better.

The other major piece of soft-

(continued on page 174)

STRANGELY ENOUGH, CONSIDERING THE SIZE AND COMPLEXITY OF THE COMPUTER AS A WHOLE, THE PC'S FIRMWARE MAY BE ITS BEST-ENGINEERED PART.

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(continued from page 171)

ware that affects our perception of the operation of the machine is the operating system. IBM chose MS-DOS, Microsoft's improved version of CP/M, as IBM DOS. It is mostly "improved" in that command names are more meaningful to the average human being. Beyond that, discussion continues regarding its merits compared to CP/M, with IBM DOS usually favored.

Unfortunately, comparison to CP/M is misplaced. IBM's operating system for the PC is better compared to operating systems for small mini-computers because the PC is expected to provide the same kind of power and functionality. In these comparisons, DOS suffers badly, and is shown to be a primitive environment. In fact, it does not compare well with the operating systems available on the unsophisticated mini-computers of eight or ten years ago.

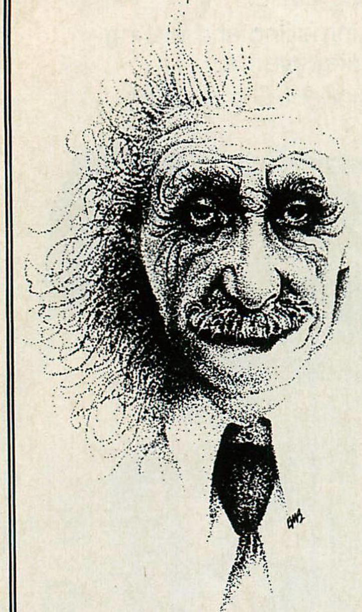
It is possible that these problems will diminish as the UNIX's and XENIX's of the world arrive on the PC. They will diminish, however, at the expense of main memory, and these new operating systems and their associated superstructures have yet to be proven.

OF ALL THE DECISIONS MADE REGARDING THE DESIGN OF THE MACHINE, THE MAJORITY WERE GOOD.

RIGHT OR WRONG?

Is the PC the right "tool for modern times?" Probably. Of all the decisions made regarding the design of the machine, we would have to say that the majority were good. Some bad ones have already been adjusted in new revisions of the machine. Others will be fixed via new software or subsequent hardware models. And a few will linger.

No matter what its failings, the PC is still a system of remarkable flexibility and considerable power. □



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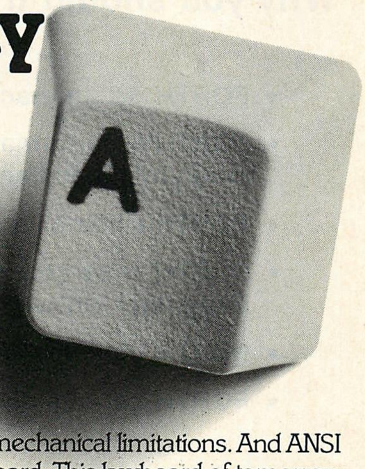

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(continued from page 91)

hand-tailoring vanishes. A much better solution is for the compiler to produce a listing of the object code that was produced in a pseudo-assembler form. This can serve as a guide in the rare cases when a function is re-written in assembler language.

On computers with memory limits of 64K bytes or less, splitting the compiler's job was often necessary if the compiler was to support the full C language. The IBM PC does not have this limit on memory size so the compiler can be implemented the right way.

Avoid CP/M "Retreads"

Some compilers offered for the IBM PC are actually re-worked versions of compilers for 8080/Z-80 based CP/M systems. Since the processor architecture and memory limits for which these products were designed were more limited, you will be getting a product that compiles too slowly, produces poor code and probably does not support the full features of C.

Be Realistic about Costs

Accept the costs necessary to get a good compiler and an adequate hardware configuration. If you can not afford to buy a good compiler or the hardware configuration it requires, you will be much better off to stick to BASIC.

Prepare for Some Frustration

At present, no compiler product for any language is as easy to use or as well documented as the better word processor or spreadsheet products. You will have to work harder and endure more frustration to learn to use C than to use an application package.

AVOID CP/M RETREADS. YOU WILL BE GETTING A PRODUCT THAT COMPILES TOO SLOWLY, PRODUCES POOR CODE, AND PROBABLY DOES NOT SUPPORT THE FULL FEATURES OF C.

Putting this Advice into Practice

After you know what to look for, you still have to dig out the answers. While you may not be able to answer all the questions, the following steps can reduce the risk that you will make a bad purchase.

Most compiler vendors run ads in the major computer magazines, such as *PC*, *PC Tech Journal*, and others. The ads can answer some questions such as whether the compiler supports the full language or whether it requires using the assembler to complete compilation.

You should buy a copy of the Kernighan and Ritchie book so that you can understand what standard C includes and what the features mentioned in the product ads mean.

A few reviews of C compilers and collections of benchmark results have been published. While the information presented in reviews is usually incomplete, some results on compiling and execution speed are available. A list of useful reviews and benchmark articles follows the article.

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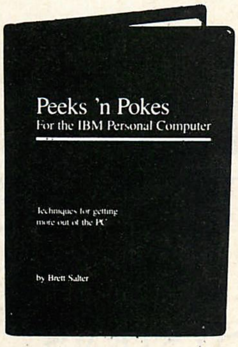

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If you belong to an IBM PC user's group, look for members already using C. Talking to someone who has been using a C compiler can lower the risk of buying a bad product.

Contact C compiler vendors and ask for more information about their product. After you have read the product literature, ask the vendor to answer any remaining items from the checklist. Most of the vendors are quite small and are willing to answer questions. (Calling seems to work better than writing.)

BEFORE YOU BUY A C COMPILER, BUY THE DOCUMENTATION AND READ IT CAREFULLY. IF THE DOCUMENTATION SEEMS INCOMPLETE OR POORLY WRITTEN, THINK TWICE BEFORE BUYING THE PRODUCT.

Before you buy a C compiler, try to look at the documentation (even if you have to buy it) and read it carefully. If the documentation seems incomplete or poorly written, think twice before buying the product.

Before you order a product, be sure that it is actually being delivered. Many companies advertise months before the product is ready for shipment.

A list of vendors of C compilers is included to give you a start. □

At the time of this writing not all C compilers listed were commonly available. Because there are so many C compilers available and because the interest in them continues to grow, in future issues of the Tech Journal *we'll evaluate and review as many C compilers as possible.*

—*W.F.*

Bill Hunt is working on a book on software tools in C.

REFERENCES

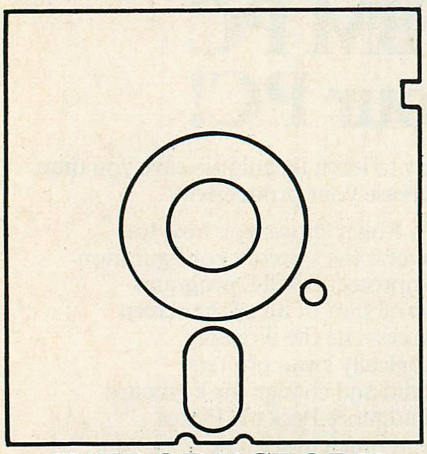
B. W. Kernighan and D. M. Ritchie, The C Programming Language. Prentice Hall, Inc., Englewood Cliffs, New Jersey. 1978. Since this is the de facto definition of the C language, you should have it on hand when you are choosing a C compiler.

J. Gilbreath and G. Gilbreath, "Eratosthenes Revisited: Once More Through the Sieve." *Byte,* January 1983, page 283. Many Pascal and C compilers were tested using the prime number sieve benchmark program. An earlier article in Byte in September 1981 contained more results with the same benchmarks.

W. Fastie. "IBM Images." *Creative Computing,* February 1983, page 278. More benchmarks for various languages on the IBM PC using the sieve program. The November 1982 column began this series.

F. Derfler, Jr. "Lattice C Compiler brings UNIX closer to micros." *Infoworld,* October 25, 1982, page 47. The Lattice C compiler is reviewed. The product is recommended but most of the questions I pose in Table 1 are not answered. The review is reprinted in the *Infoworld Report Card,* a collection of software reviews from *Infoworld.*

H. Hinsch. "Five C Language Compilers." *PC Magazine,* February 1983, page 210. All five compilers reviewed ran on the IBM PC under DOS. This is one of the better reviews of compilers I have seen, clearly showing some of the compilers to be unsatisfactory.



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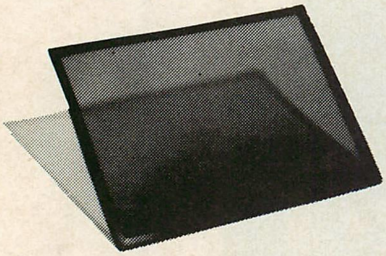

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DIRECTIONS

(continued from page 14)

cause so many people, software developers and users alike, have a genuine need to know. There is simply no other source for such detailed, exacting information about the PC. It's a big part of what *PC Tech Journal* is all about.

It's also the tip of the iceberg. We haven't come so far, no matter what you might think, that we can just walk into a store, buy a computer, and have it doing useful work, *in the context of the organization in which it is installed*, by the next day. Sure, the benefits of spreadsheet calculators come very fast, but usually within a limited context. Do the data come from the company's mainframe? Does the output return there? Are changes generated by one area propagated to other areas? How many copies of a data base are there, really?

Communications, distributed processing, office automation, networking, and the whole business of using small computers connected to larger systems is going to be a major focus of *PC Tech Journal*. There are so many complex technical issues here that we can all be quickly overwhelmed; we hope to sort some of them out for you (and us). At the very least, we are going to try to provide some much-needed education in these areas so that the fundamental issues can be better understood.

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Quite an entree, eh? We haven't forgotten the other six courses either. A glance through this issue will give you a precursor of things to come. Source listings, not for this week's favorite game, but for significant, useful programs. Our Tech Notebook, to improve your understanding of the PC. Product reviews, written by experts on the subject. And articles you probably can't find anywhere else.

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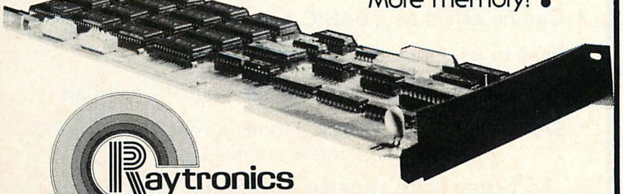

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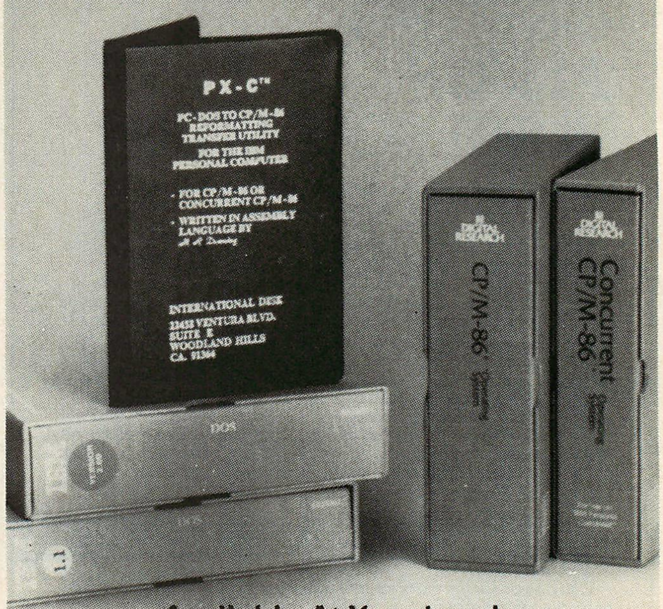

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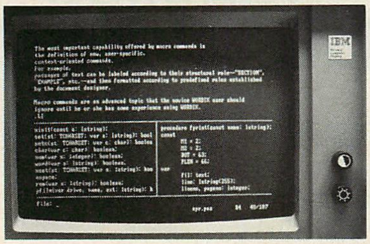

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CIRCLE NO. 179 ON READER SERVICE CARD

IBM Color/Graphics Adapter

Program 1, Page 138

```
1000 'File: BOXES.BAS
1010 'Auth: Thomas V. Hoffmann
1020 'Edit: TVH  18-April-83  6:00pm
1030 '
1040 DEFINT A-Z
1050 '----------
1060 'CGA Definitions
1070 '
1080 MODEREG = &H3D8: COLORREG = &H3D9    '-- CGA Control Registers
1090 MODESAVE=&H465: COLORSAVE=&H466 '-- BIOS Saves regs here
1100 CRTREG=&H3D4: CRTDATA=&H3D5     '-- 6845 CRT control regs
1110 HIRES=1: GRAPH=2: BW=4: VIDEO=8     '-- Mode register bits
1120 G640=16: BLINK=32                   '-- ..
1130 '
1140 '----------
1150 ' Switch to Color Adapter
1160 '   (If no mono adapter installed,
1170 '   change 1 to 0 in next line)
1180 '
1190 MONO = 1    '-- Return to mono adapter
1200 GOSUB 7000
1210 '
1220 '----------
1230 ' Set F10 for Exit
1240 '
1250 KEY ON: KEY (10) ON
1270 ON KEY(10) GOSUB 9900
1280 '
1290 '----------
1300 'Select 640 Color Mode
1310 '
1320 SCREEN 2: KEY OFF: CLS
1330 DEF SEG=0
1340 MODE = PEEK (MODESAVE) AND NOT BW
1350 POKE MODESAVE,MODE: OUT MODEREG,MODE
1360 '
3000 '----------
3010 ' Repeat Random 40x20 Boxes, PAINTed With Color
3020 '
3030 WHILE 1
3040 '-- Generate Random (X,Y) for Upper Left Corner
3050     X=RND*640: Y=RND*200
3060 '-- Draw White Box Outline
3070     LINE  (X,Y)-STEP (40,20),1,B
3080 '-- Draw Nested Box Filled in Black
3090     LINE (X+1,Y+1)-STEP(38,18),0,BF
3100 '-- Pick Next Color Pattern in Sequence
3110     C = (C+1) MOD 15
3120     IF C = 0 THEN GOTO 3150 '-- Can't PAINT pattern 0
3130 '-- Paint Box with Color Pattern
3140     PAINT (X+3,Y+3),CHR$(C*&H11)
3150 WEND
3160 '
3170 '----------
7000 '----------
7010 ' Switch to Color/Graphics Display
7020 '
7030 DEF SEG=0: A=PEEK(&H410): POKE &H410,(A AND &HCF) OR &H20
7040 WIDTH 40: SCREEN 1: SCREEN 0: LOCATE ,,1,6,7
7050 RETURN
7060 '
7100 '----------
7110 ' Conditionally Switch to Monochrome Display
7120 '
7130 IF MONO <> 1 THEN LOCATE 1,1: RETURN
7140 DEF SEG=0: A=PEEK(&H410): POKE &H410,(A OR &H30)
7150 WIDTH 80: LOCATE ,,1,12,13: SCREEN 0,0,0
7160 KEY ON
7170 RETURN
7180 '
9900 '----------
9910 ' F10 Gets Here to Exit
9920 '
9930 GOSUB 7100 '-- return to monochrome
9940 END        '-- and quit
```

Color/Graphics, Prog. 2, Page 172

```
1000 'File: KSCOPE.BAS
1010 'Auth: Thomas V. Hoffmann
1020 'Edit: TVH  18-April-83  6:00pm
1030 '
1040 DEFINT A-Z
1050 '----------
1060 'CGA Definitions
1070 '
1080 MODEREG=&H3D8: COLORREG=&H3D9   '-- CGA Control Registers
1090 MODESAVE=&H465: COLORSAVE=&H466 '-- BIOS Saves Regs here
1100 CRTREG = &H3D4: CRTDATA = &H3D5 '-- 6845 CRT control regs
1110 HIRES=1: GRAPH=2: BW=4: VIDEO=8 '-- Mode register bits
1120 G640=16: BLINK=32               '-- ..
1130 '
1140 '----------
1150 ' Set MONO to 1 if both adapters installed
1160 '             0 if color adapter only
1170 '
1180 MONO = 1
1190 '
1200 '----------
1210 ' Set F3=Load Picture, F4=Save Picture, F10=Exit
1220 '
1230 KEY ON: KEY (3) ON: KEY (4) ON: KEY (10) ON
1232 ON KEY(3) GOSUB 9300
1234 ON KEY(4) GOSUB 9400
1240 ON KEY(10) GOSUB 9900
1250 '
1260 '----------
1270 ' Initialize Color, Cycle Counter
1280 '
1290 PCOLOR=1
1300 TIMES=0
1310 INPUT "How many cycles per color change";MAXTIMES
1312 INPUT "Highest color number"; MAXCOLOR
1320 '----------
1330 'Setup Color Adapter for 160x100 Alpha Graphics
1340 '
1350 DEF SEG=0
1360 MODE = 0   '-- Turn off Video During Setup
1370 POKE MODESAVE,MODE: OUT MODEREG,MODE
1380 POKE COLORSAVE,0: OUT COLORREG,0
1390 '
1400 '-- Load New Parameters into 6845 CRT Controller
1410 FOR REG = 0 TO 11
1420   READ REGDATA
1430   OUT CRTREG, REG: OUT CRTDATA, REGDATA
1440 NEXT REG
1450 '
1460 '-- Set Mode for 80 Column Color and Enable
1470 MODE = HIRES + VIDEO
1480 POKE MODESAVE,MODE: OUT MODEREG,MODE
1490 '
1500 '-- Clear Screen: Character = &HDE, Attributes = 0
1510 DEF SEG = &HB800
1520 FOR CHAR = 0 TO 15998 STEP 2: POKE CHAR,&HDE: NEXT CHAR
1530 FOR ATTR = 1 TO 15999 STEP 2: POKE ATTR,0   : NEXT ATTR
1540 '
1550 '----------
1560 ' Generate Random Coordinates and Color
1570 '   and Reflect 8 Ways
1580 '
1590 BEEP
1600 WHILE 1 '-- Repeat until F10 struck
1610   TIMES = TIMES + 1
1620     IF  TIMES  > MAXTIMES THEN TIMES=0: PCOLOR=(PCOLOR+1) MOD (MAXCOLOR+1)
1630   X = RND*79: Y= RND*49
1640   GOSUB 4000
1650   IF X<79 THEN SWAP X,Y: GOSUB 4000
1660 WEND
4000 '----------
4010 ' Plot PCOLOR Symmetrically in each quadrant
4015 '
4020   X=159-X: GOSUB 5000
4030   Y= 99-Y: GOSUB 5000
4040   X=159-X: GOSUB 5000
4050   Y= 99-Y: GOSUB 5000
4060 RETURN
5000 '----------
5010 ' Plot PCOLOR at (X,Y)
5020 '
```

(continued on p. 184)

(Color Graphics/prog. 2/cont. from page 183)

```
5030 PIXEL = X+(Y*160): PIXELADDR = (PIXEL AND &HFFFE) + 1
5040 NIBBLE = PIXEL MOD 2
5050 IF NIBBLE=0 THEN POKE PIXELADDR,(PEEK(PIXELADDR)AND &HF) + PCOLOR * &H10
5060 IF NIBBLE=1 THEN POKE PIXELADDR,(PEEK(PIXELADDR) AND &HF0) + PCOLOR
5070 RETURN
7000 '----------
7010 ' Switch to Color/Graphics Display
7020 '
7030 DEF SEG=0: A=PEEK(&H410): POKE &H410,(A AND &HCF) OR &H20
7040 WIDTH 40: SCREEN 1: SCREEN 0: LOCATE ,,1,6,7
7050 RETURN
7060 '
7100 '----------
7110 ' Conditionally Switch to Monochrome Display
7120 '
7130 IF MONO <> 1 THEN GOSUB 7000: RETURN
7140 DEF SEG=0: A=PEEK(&H410): POKE &H410,(A OR &H30)
7150 WIDTH 80: LOCATE ,,1,12,13: SCREEN 0,0,0
7160 KEY ON
7170 RETURN
7180 '
8000 '----------
8010 ' Initial Data for 6845 (80x100 characters)
8020 '
8030 DATA 113  :'-- R0  Horizontal Total
8040 DATA  80  :'-- R1  Horizontal Displayed
8050 DATA  90  :'-- R2  Horizontal Sync Position
8060 DATA  10  :'-- R3  Horizontal Sync Width
8070 DATA 127  :'-- R4  Vertical Total
8080 DATA   6  :'-- R5  Vertical Adjust
8090 DATA 100  :'-- R6  Vertical Displayed
8100 DATA 112  :'-- R7  Vertical Sync Position
8110 DATA   2  :'-- R8  Interlace Mode (non-interlace)
8120 DATA   1  :'-- R9  Maximum Scan Line Address
8130 DATA  32  :'-- R10 Cursor Start (disables cursor display)
8140 DATA   0  :'-- R11 Cursor End
8150 '----------
9300 '----------
9310 ' F3 - Load Picture File
9320 '
9330 INPUT "Load from file: ", PIC$
9340 BLOAD PIC$,0
9345 INPUT "Press enter to continue...",JUNK$
9350 RETURN
9360 '
9400 '----------
9410 ' F4 - Save Picture File
9420 '
9430 INPUT "Save in file: ", PIC$
9440 BSAVE PIC$,0,16000
9445 INPUT "Press enter to continue...",JUNK$
9450 RETURN
9460 '
9900 '----------
9910 ' F10 - Exit
9920 '
9930 GOSUB 7100 '-- return to monochrome
9940 END        '-- and quit
9999 END
```

Anatomy and Construction of XB: Page 61

```
1 ' File:  xb.bas
2 ' Auth:  Richard Foard
3 ' Edit:  rmf  13-Mar-83  10:00pm
4 ' Copyright (c) 1982 Richard M. Foard
5 '
6 DIM LABSTK(25),GLABVALS(1000),ULABVALS(1000),ULABTEXT$(1000)
899 GOTO 1000
900 DEF FNALPHA(C$)=(C$>="a" AND C$<="z") OR (C$>="A" AND C$<="Z")
901 DEF FNNUMERIC(C$)=C$>="0" AND C$<="9"
903 DEF FNUPPER$(C$)=CHR$(+32*(C$>="a")+ASC(C$))
999 RETURN
1000 PASS=1
1010 GOSUB 10000 'initialize
2000 GOSUB 31000 'readline
2200 GOSUB 4000 'proc line
2400 IF NOT(EOF(INCHAN)) THEN 2000
2460 GOSUB 55000 'pass 2
2465 GOSUB 55200 'finish ulabs
2467 GOSUB 55500 'finish errs
2470 CLOSE INCHAN
2480 CLOSE OUTCHAN
2490 PRINT "Compilation complete"
2500 STOP
4000 '----------
4010 ' proc line
4020 '
4030 GOSUB 50500 'scan nb
4032 IF FNNUMERIC(TOKEN$) THEN 4030 'skip line numbers
4034 WHILE TTYPE=ULAB
4035   GOSUB 46000 'def ulab
4036   GOSUB 50500 'scan nb
4037 WEND
4039 IF TTYPE=EOL THEN RETURN
4040 IF TTYPE=SCANERROR THEN RETURN
4050 IF TTYPE <> SNAME THEN 4600
4060 IF TOKEN$ <> "IF" THEN 4090
4070   GOSUB 40000 'proc if
4080   RETURN
4090 IF TOKEN$ <> "ELSE" THEN 4120
4100   GOSUB 40500 'proc else
4110   RETURN
4120 IF TOKEN$ <> "ELSEIF" THEN 4150
4130   GOSUB 41000 'proc elseif
4140   RETURN
4150 IF TOKEN$ <> "ENDIF" THEN 4170
4160   GOSUB 41500 'proc endif
4165   RETURN
4170 IF TOKEN$ <> "REPEAT" THEN 4200
4180   GOSUB 42000 'proc repeat
4190   RETURN
4200 IF TOKEN$ <> "WHILE" THEN 4230
4210   GOSUB 42500 'proc while
4220   RETURN
4230 IF TOKEN$ <> "UNTIL" THEN 4260
4240   GOSUB 43000 'proc until
4250   RETURN
4260 IF TOKEN$ <> "ENDREP" THEN 4320
4270   GOSUB 43500 'proc endrep
4280   RETURN
4320 IF TOKEN$ <> "DO" THEN 4350
4330   GOSUB 44500 'proc do
4340   RETURN
4350 IF TOKEN$ <> "PROCEDURE" THEN 4380
4360   GOSUB 45000 'proc procedure
4370   RETURN
4380 IF TOKEN$ <> "ENDPROC" THEN 4600
4390   GOSUB 45500 'proc endproc
4400   RETURN
4600 'endif
4660 GOSUB 59000 'copy to eol
4670 GOSUB 30200 'putline
4999 RETURN
10000 '----------
10010 ' initialize
10020 '
10030 GOSUB 21000 'init scan
10040 GOSUB 30000 'init put
10050 GOSUB 30500 'init labtabs
10060 GOSUB 30700 'init labstk
10070 GOSUB 31500 'init readline
10080 GOSUB 900   'define functions
10090 GOSUB 50000 'init symtabs
10100 GOSUB 53000 'init files
10110 GOSUB 51000 'init screen
10999 RETURN
20000 '----------
20010 'scan --
20020 '  sets 'token$' = next token in 'inline$'
20030 '       'ttype'  = token class
20040 '
20050 IF ASC(CHAR$)<>EOL AND ASC (CHAR$) <> 12 THEN 20090
20060   TTYPE=EOL
20070   TOKEN$=""
20080   GOTO 20550
20090 'elseif
20100 IF ASC(CHAR$)<>&042 THEN 20140
20110   GOSUB 21500 'proc quoted
20130   GOTO 20550
20140 'elseif
20280 IF CHAR$<>"@" THEN 20390
20290   GOSUB 21400 'nxtc u
20360   GOSUB 23110 'proc ulab
```

(continued on p. 186)

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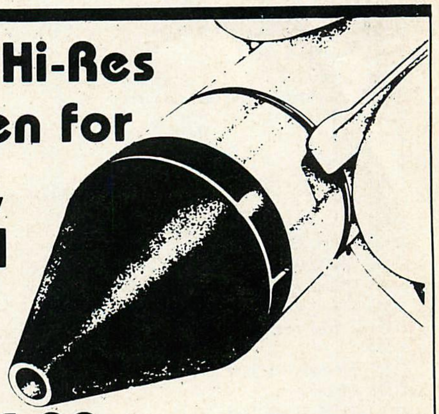

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CIRCLE NO. 209 ON READER SERVICE CARD

(XB/continued from p. 184)

```
20380   GOTO 20550
20390 'elseif
20400 IF NOT FNALPHA(CHAR$) THEN 20430
20420   GOSUB 23300 'proc name
20425   GOTO 20550
20430 'else
20440   IF CHAR$<>" " AND ASC(CHAR$) <> 9 THEN 20500
20450     TOKEN$=" "
20460     TTYPE=ASC(" ")
20470     GOSUB 21400 'nxtc u
20480     IF CHAR$=" " THEN 20470
20490     GOTO 20540
20500   'else
20510     TOKEN$=CHAR$
20520     TTYPE=ASC(CHAR$)
20530     GOSUB 21400 'nxtc u
20540   'endif
20550 'endif
20560 RETURN
20999 RETURN
21000 '----------
21010 ' init scan
21020 '
21030 EOL=1
21040 QSTR=2
21060 GLAB=3
21070 ULAB=4
21080 SNAME=5
21090 SCANERROR=6
21199 RETURN
21200 '----------
21210 ' init line scan
21220 '
21230 INLINELEN=LEN(INLINE$)
21240 INI=1
21250 GOSUB 21400 'nxtc u
21299 RETURN
21300 '----------
21310 ' nxtc -- sets 'char$' to next input character
21320 '
21330 IF INI<=INLINELEN THEN 21350
21340   CHAR$=CHR$(EOL)
21345   GOTO 21380
21350 'else
21360   CHAR$=MID$(INLINE$,INI,1)
21370   INI=INI+1
21380 'endif
21390 RETURN
21400 '----------
21410 ' nxtc u
21420 '
21430 GOSUB 21300 'nxtc
21440 CHAR$=FNUPPER$(CHAR$)
21499 RETURN
21500 '----------
21510 ' proc quoted
21520 '
21530 TOKEN$=CHR$(&042)
21535 PQLEN=0
21540 GOSUB 21300 'nxtc
21550 IF ASC(CHAR$)=&042 OR PQLEN=255 THEN 21590
21560   TOKEN$=TOKEN$+CHAR$
21570   PQLEN=PQLEN+1
21575   GOSUB 21300 'nxtc
21580   GOTO 21550
21590 'endloop
21600 IF PQLEN<255 THEN 21660
21610   ERMSG$="String too long"
21620   GOSUB 60000 'error
21630   TTYPE=SCANERROR
21640   TOKEN$=""
21650   GOTO 21690
21660 'else
21670   TOKEN$=TOKEN$+CHR$(&042)
21680   TTYPE=QSTR
21685   GOSUB 21400 'nxtc u
21690 'endif
21799 RETURN
23100 '----------
23110 ' proc ulab
23120 '
23130 GOSUB 23300 'proc name
23140 IF TTYPE=SNAME THEN 23190
23150   ERMSG$="Improper user label"
23160   GOSUB 60000 'error
23170   TTYPE=SCANERROR
23180   TOKEN$=""
23185   GOTO 23210
23190 'else
23200   TTYPE=ULAB
23210 'endif
23299 RETURN
23300 '----------
23310 ' proc name
23320 '
23330 IF FNALPHA(CHAR$) THEN 23380
23340   ERMSG$="Improper name"
23350   GOSUB 60000 'error
23360   TTYPE=SCANERROR
23370   GOTO 23490
23380 'else
23385   TOKEN$=""
23390   IF (NOT FNALPHA(CHAR$)) AND (NOT FNNUMERIC(CHAR$)) THEN 23440
23400     TOKEN$=TOKEN$+CHAR$
23410     GOSUB 21400 'nxtc u
23420     GOTO 23390
23430   'endloop
23440   IF CHAR$<>"#" AND CHAR$<>"%" AND CHAR$<>"$" AND CHAR$<>"!" THEN 23470
23450     TOKEN$=TOKEN$+CHAR$
23460     GOSUB 21400 'nextc u
23470   'endif
23480   TTYPE=SNAME
23490 'endif
23999 RETURN
30000 '----------
30010 ' init put
30020 '
30030 OUTLINE$=" 10 "
30040 OUTNUM=10
30045 OUTINC=10
30099 RETURN
30100 '----------
30110 ' put -- appends 'out$' to 'outline$'
30120 '
30130 OUTLINE$=OUTLINE$+POUT$
30199 RETURN
30200 '----------
30210 ' putline
30220 '
30230 PRINT# OUTCHAN,OUTLINE$
30240 OUTNUM=OUTNUM+OUTINC
30250 OUTLINE$=STR$(OUTNUM)+" "
30499 RETURN
30500 '----------
30510 ' init labtabs
30520 '
30530 NEXTGLAB=65529!
30540 NEXTULAB=0
30599 RETURN
30600 '----------
30610 ' genlab -- sets 'label$', 'labelval'
30620 '
30630 LABEL$=STR$(NEXTGLAB)
30640 LABELVAL=NEXTGLAB
30650 NEXTGLAB=NEXTGLAB-1
30699 RETURN
30700 '----------
30710 ' init labstk
30720 '
30730 LABTOP=0
30799 RETURN
30800 '----------
30810 ' pushlab -- pushes 'labelval'
30820 '
30830 LABSTK(LABTOP)=LABELVAL
30840 LABTOP=LABTOP+1
30850 IF LABTOP>25 THEN PRINT "Label stack overflow": STOP
30899 RETURN
30900 '----------
30910 ' poplab -- pops 'labelval', set label$
30920 '
30930 LABTOP=LABTOP-1
30940 IF LABTOP<0 THEN PRINT "Label stack underflow": STOP
30950 LABELVAL=LABSTK(LABTOP)
30960 LABEL$=STR$(LABELVAL)
30999 RETURN
31000  ----------
```

(continued on p. 188)

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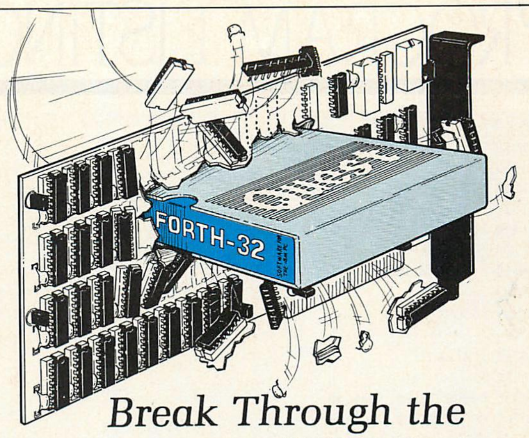

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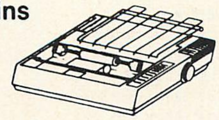

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CIRCLE NO. 202 ON READER SERVICE CARD

(XB/continued from p. 186)

```
31010 ' readline -- reads 'inline$'
31020 '
31030 LINE INPUT# INCHAN,INLINE$
31040 GOSUB 21200 'init line scan
31499 RETURN
31500 '----------
31510 ' init readline
31520 '
31999 RETURN
40000 '----------
40010 ' proc if
40020 '
40030 GOSUB 30600 'genlab
40040 GOSUB 30800 'pushlab
40050 GOSUB 30600 'genlab
40060 GOSUB 30800 'pushlab
40070 POUT$="IF NOT("
40080 GOSUB 30100 'put
40090 GOSUB 50500 'scan nb
40120 GOSUB 59000 'copy to eol
40130 POUT$=") THEN "+LABEL$
40140 GOSUB 30100 'put
40150 GOSUB 30200 'putline
40499 RETURN
40500 '----------
40510 ' proc else
40520 '
40530 GOSUB 30900 'poplab
40540 TVAL1=LABELVAL
40560 GOSUB 30900 'poplab
40570 POUT$="GOTO "+LABEL$
40580 GOSUB 30100 'put
40590 GOSUB 30200 'putline
40592 TVAL2=LABELVAL
40594 LABELVAL=TVAL1
40596 GOSUB 50100 'place glab
40598 LABELVAL=TVAL2
40620 GOSUB 30800 'pushlab
40630 GOSUB 30800 'pushlab
40999 RETURN
41000 '----------
41010 ' proc elseif
41020 '
41030 GOSUB 30900 'poplab
41040 TVAL1=LABELVAL
41060 GOSUB 30900 'poplab
41070 POUT$="GOTO "+LABEL$
41080 GOSUB 30100 'put
41090 GOSUB 30200 'putline
41092 TVAL2=LABELVAL
41094 LABELVAL=TVAL1
41096 GOSUB 50100 'place glab
41098 LABELVAL=TVAL2
41120 GOSUB 30800 'pushlab
41130 GOSUB 30600 'genlab
41135 GOSUB 30800 'pushlab
41140 POUT$="IF NOT("
41150 GOSUB 30100 'put
41160 GOSUB 50500 'scan nb
41190 GOSUB 59000 'copy to eol
41200 POUT$=") THEN "+LABEL$
41210 GOSUB 30100 'put
41220 GOSUB 30200 'putline
41499 RETURN
41500 '----------
41510 ' proc endif
41520 '
41530 GOSUB 30900 'poplab
41531 GOSUB 50100 'place glab
41535 GOSUB 30900 'poplab
41540 GOSUB 50100 'place glab
41999 RETURN
42000 '----------
42010 ' proc repeat
42020 '
42030 GOSUB 30600 'genlab
42040 GOSUB 30800 'pushlab
42050 GOSUB 50100 'place glab
42070 GOSUB 30600 'genlab
42080 GOSUB 30800 'pushlab
42090 GOSUB 50500 'scan nb
42100 IF TTYPE <> SNAME OR TOKEN$ <> "WHILE" THEN 42130
42110    GOSUB 42500 'proc while
42120    GOTO 42170
42130 IF TTYPE <> SNAME OR TOKEN$ <> "UNTIL" THEN 42170
42140    GOSUB 43000 'proc until
42170 'endif
42499 RETURN
42500 '----------
42510 ' proc while
42520 '
42530 GOSUB 30900 'poplab
42540 GOSUB 30800 'pushlab
42550 POUT$="IF NOT("
42560 GOSUB 30100 'put
42580 GOSUB 50500 'scan nb
42590 GOSUB 59000 'copy to eol
42600 POUT$=") THEN "+LABEL$
42605 GOSUB 30100 'put
42610 GOSUB 30200 'putline
42999 RETURN
43000 '----------
43010 ' proc until
43020 '
43030 GOSUB 30900 'poplab
43040 GOSUB 30800 'pushlab
43050 POUT$="IF "
43060 GOSUB 30100 'put
43080 GOSUB 50500 'scan nb
43090 GOSUB 59000 'copy to eol
43100 POUT$=" THEN "+LABEL$
43110 GOSUB 30100 'put
43120 GOSUB 30200 'putline
43499 RETURN
43500 '----------
43510 ' proc endrep
43520 '
43530 GOSUB 30900 'poplab
43550 TVAL1=LABELVAL
43560 GOSUB 30900 'poplab
43570 POUT$="GOTO "+LABEL$
43580 GOSUB 30100 'put
43590 GOSUB 30200 'putline
43592 LABELVAL=TVAL1
43594 GOSUB 50100 'place glab
43999 RETURN
44000 '----------
44010 ' proc include
44020 '
44499 RETURN
44500 '----------
44510 ' proc do
44520 '
44550 GOSUB 50500 'scan nb
44560 IF TTYPE=SNAME THEN 44600
44570    ERMSG$="Procedure name missing"
44580    GOSUB 60000 'error
44590    RETURN
44600 'endif
44610 POUT$="GOSUB "
44620 GOSUB 30100 'put
44630 GOSUB 50200 'ulab ref
44700 GOSUB 30200 'putline
44710 GOSUB 50600 'vfy eol
44999 RETURN
45000 '----------
45010 ' proc procedure
45020 '
45030 GOSUB 50500 'scan nb
45040 IF TTYPE=SNAME THEN 45080
45050    ERMSG$="Missing procedure name"
45060    GOSUB 60000 'error
45070    RETURN
45080 POUT$="'----"+TOKEN$
45090 GOSUB 30100 'put
45100 GOSUB 46000 'def ulab
45160 GOSUB 30200 'putline
45170 GOSUB 50600 'vfy eol
45499 RETURN
45500 '----------
45510 ' proc endproc
45520 '
45530 POUT$="RETURN"
45540 GOSUB 30100 'put
45550 GOSUB 30200 'putline
45560 GOSUB 50600 'vfy eol
45599 RETURN
```

(continued on p. 191)

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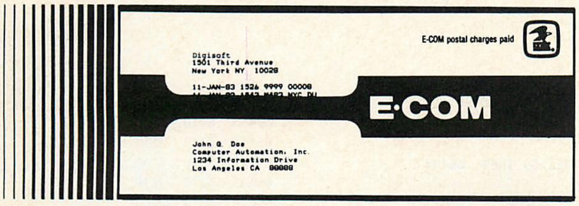

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CIRCLE NO. 111 ON READER SERVICE CARD

XB Listing 1a

```
'----------
PROCEDURE EXECCOMMAND
S=VAL(COMMAND$)
IF S<>0
  IF SWITCHDATA(S,SID)<0
    DO WARNSOUND
  ELSEIF SWITCHDATA(S,SACTIVE)>0
    DO ERRORSOUND
  ELSE
    SWITCH=S
    SWITCHDATA(SWITCH,SSTATE)=1-SWITCHDATA(SWITCH,SSTATE)
    DO SHOWSWITCH
  ENDIF
ELSE
  TRAIN$=RIGHT$(COMMAND$,1)
  FOR TRAIN=0 TO NRTRAINS-1
    IF TD(TRAIN,TID)=ASC(TRAIN$)
      CC$=LEFT$(COMMAND$,1)
      IF CC$="S"
        DO STOPTRAIN
      ELSEIF CC$="G"
        DO GOTRAIN
      ELSEIF CC$="R"
        DO REVERSETRAIN
        DO GOTRAIN
      ELSE
        DO WARNSOUND
      ENDIF
      RETURN
    ENDIF
  NEXT
DO WARNSOUND
ENDIF
ENDPROC
```

XB Listing 1b

```
2060 '----EXECCOMMAND
2070 S=VAL(COMMAND$)
2080 IF NOT(S<>0) THEN  65498
2090 IF NOT(SWITCHDATA(S,SID)<0) THEN  65496
2100 GOSUB  65495
2110 GOTO  65497
2120 IF NOT(SWITCHDATA(S,SACTIVE)>0) THEN  65494
2130 GOSUB  65493
2140 GOTO  65497
2150 SWITCH=S
2160 SWITCHDATA(SWITCH,SSTATE)=1-SWITCHDATA(SWITCH,SSTATE)
2170 GOSUB  890
2180 GOTO  65499
2190 TRAIN$=RIGHT$(COMMAND$,1)
2200 FOR TRAIN=0 TO NRTRAINS-1
2210 IF NOT(TD(TRAIN,TID)=ASC(TRAIN$)) THEN  65491
2220 CC$=LEFT$(COMMAND$,1)
2230 IF NOT(CC$="S") THEN  65489
2240 GOSUB  65488
2250 GOTO  65490
2260 IF NOT(CC$="G") THEN  65487
2270 GOSUB  65486
2280 GOTO  65490
2290 IF NOT(CC$="R") THEN  65485
2300 GOSUB  65484
2310 GOSUB  65486
2320 GOTO  65490
2330 GOSUB  65495
2340 RETURN
2350 NEXT
2360 GOSUB  65495
2370 RETURN
```

```
   .
   .
   .
65484  GOTO  3550
65485  GOTO  2330
65486  GOTO  3510
65487  GOTO  2290
65488  GOTO  3470
65489  GOTO  2260
65490  GOTO  2340
65491  GOTO  2350
65492  GOTO  2350
65493  GOTO  3760
65494  GOTO  2150
65495  GOTO  3650
65496  GOTO  2120
65497  GOTO  2180
65498  GOTO  2190
65499  GOTO  2370
```

(continued from page 161)

it clocks in at a depressing fifteen source lines per minute, and slower if the program being compiled contains long and complex lines. My "good news" comment that developing big programs in XB is *feasible* must be tempered with the bad news that it's *tedious*. Some obvious ways of improving XB's performance suggest themselves. First, the compiler has been compiled with MicroSoft's BASIC compiler. This yielded a performance improvement of about 400%, up to a blazing (by comparison) one source line per second. Second, XB spends the great bulk of its time scanning the source program and parceling it into names, strings and other lexical elements. It composes lexical elements (tokens) character by character, using BASIC string concatenation operations in a straightforward, "brute force" way. I don't know the intimate details of MicroSoft's BASIC interpreter, but I suspect that a much faster approach to this task could be devised easily, perhaps by using arrays of characters for storing tokens instead of using BASIC strings.

GIVEN THE UNDERLYING FACILITIES OF THE SYMBOL TABLE MANAGER, STACK MAINTENANCE ROUTINES, AND CODE GENERATION PRIMITIVES, CONSTRUCTING THE SEMANTIC ROUTINES WAS RELATIVELY SIMPLE.

Conclusions — The Good News

Like most programmers, I'm reasonably proud of my inventions, so readers should take this with their customary number of grains of salt. XB is a successful experiment in that it has provided me with a well-structured language which doesn't hide from its users any of the extensive built-in support that comes in IBM BASIC, like its graphics primitives. The XB compiler makes it *feasible* to write complex, and even large programs in a language which doesn't eventually overwhelm its user with complexity and superfluous details. I have, in fact, written a number of substantial programs using XB, from which a few specimens have been drawn. Listing 1a is an XB fragment, while listing 1b is the XB compiled output corresponding to 1a. (See above.)

XB also provides me with a simple base for experimenting with new language constructs. Because its syntax is so simple, the language and compiler are easily extended to include new facilities. The underpinnings of the scanner, stack and symbol table managers, and code generation primitives are already present to support the addition of new semantic routines without extensive programming. □

A complete listing of the XB compiler follows on page 184. —WF

Richard M. Foard is Vice President of Software Development for the Baltimore-based Travel Technology Corporation; he occasionally gets cranky about language design.

(XB/continued from p. 188)

```
46000 '----------
46010 ' def ulab
46020 '
46030 GOSUB 50300 'lookup ulab
46040 IF LABELINDEX<0 THEN 46130
46050   IF LABELLOC<0 THEN 46090
46060     ERMSG$="multiple definition: "+TOKEN$
46070     GOSUB 60000 'error
46080     GOTO 46110
46090   'else
46095     GLABVALS(65529!+LABELLOC)=OUTNUM
46100     ULABVALS(LABELINDEX)=OUTNUM
46110   'endif
46120   GOTO 46180
46130 'else
46140   ULABVALS(NEXTULAB)=OUTNUM
46150   ULABTEXT$(NEXTULAB)=TOKEN$
46160   NEXTULAB=NEXTULAB+1
46170   IF NEXTULAB>1000 THEN PRINT "Too many labels" : STOP
46180 'endif
46190 GOSUB 50500 'scan nb 'consume : if pres. else fetch eol
46499 RETURN
50000 '----------
50010 ' init symtabs
50020 '
50030 FOR I=0 TO 1000
50040   GLABVALS(I)=-1
50050   ULABVALS(I)=-1
50060 NEXT
50070 NEXTULAB=0
50099 RETURN
50100 '----------
50110 ' place glab
50120 '
50130 GLABVALS(65529!-LABELVAL)=OUTNUM
50199 RETURN
50200 '----------
50205 ' ulab ref
50210 '
50215 GOSUB 50300 'lookup ulab
50220 IF LABELINDEX>=0 THEN 50245
50225   LABELINDEX=NEXTULAB: NEXTULAB=NEXTULAB+1
50230   ULABTEXT$(LABELINDEX)=TOKEN$
50235   GOSUB 30600 'genlab
50240   ULABVALS(LABELINDEX)=-LABELVAL
50245 'endif
50250 POUT$=STR$(ABS(ULABVALS(LABELINDEX)))
50255 GOSUB 30100 'put
50299 RETURN
50300 '----------
50310 ' lookup ulab -- label in 'token$', sets 'labelloc', 'labelindex'
50320 '
50340 IF NEXTULAB=0 THEN LABELINDEX=-1: RETURN
50350 FOR LABELINDEX=0 TO NEXTULAB-1
50360   IF ULABTEXT$(LABELINDEX)<>TOKEN$ THEN 50390
50370   LABELLOC=ULABVALS(LABELINDEX)
50380   RETURN
50390 NEXT
50400 LABELINDEX=-1
50499 RETURN
50500 '----------
50510 ' scan nb
50520 '
50530 GOSUB 20000 'scan
50540 IF TOKEN$=" " THEN 50530
50599 RETURN
50600 '----------
50610 ' vfy eol
50620 '
50630 GOSUB 50500 'scan nb
50640 IF TTYPE=EOL OR TTYPE=CDELIM THEN RETURN
50650 ERMSG$="Extraneous words after statement"
50660 GOSUB 60000 'error
50699 RETURN
51000 '----------
51010 ' init screen
51020 '
51030 CLS
51040 LOCATE 1,1: PRINT USING "\      \ XB V1.00 (13-Mar-83)";TIME$;
51099 RETURN
53000 '----------
53010 ' init files
53020 '
53030 INCHAN=1
53040 OUTCHAN=2
53050 INPUT "Input file: ",INNAME$
53060 INPUT "Output file: ",OUTNAME$
53070 OPEN INNAME$ FOR INPUT AS INCHAN
53080 OPEN OUTNAME$ FOR OUTPUT AS OUTCHAN
53090 RETURN
55000 '----------
55010 ' pass 2
55020 '
55030 GOSUB 30000 'init put
55040 OUTNUM=65529!
55045 OUTLINE$="65529 "
55050 OUTINC=-1
55060 PATCHNR=0
55070 WHILE OUTNUM>NEXTGLAB
55080   POUT$=" GOTO "+STR$(GLABVALS(PATCHNR))
55090   GOSUB 30100 'put
55100   GOSUB 30200 'putline
55105   PATCHNR=PATCHNR+1
55110 WEND
55199 RETURN
55200 '----------
55210 ' finish ulabs
55220 '
55230 IF NEXTULAB=0 THEN RETURN
55240 FOR I=0 TO NEXTULAB-1
55250   IF ULABVALS(I)>=0 THEN 55300
55260     ERMSG$="Undefined label: "+ULABTEXT$(I)
55270     GOSUB 60000 'error
55300   'endif
55310 NEXT
55320 RETURN
55500 '----------
55510 'finish errs
55520 '
55530 CLS
55540 IF ERCNT=0 THEN PRINT "No errors detected"
              ELSE PRINT USING "#### error(s) detected"; ERCNT
55599 RETURN
59000 '----------
59010 ' copy to eol
59020 '
59030 WHILE TTYPE<>EOL
59040   IF TTYPE<>ULAB THEN 59100
59050     GOSUB 50200 'ulab ref
59060     GOTO 59200
59100   'else
59110     POUT$=TOKEN$
59120     GOSUB 30100 'put
59200   'endif
59205   GOSUB 20000 'scan
59210 WEND
59299 RETURN
60000 '----------
60010 ' error -- displays 'ermsg$'
60020 '
60030 ERCNT=ERCNT+1
60040 PRINT "XB Error: ";
60050 PRINT ERMSG$
60070 RETURN
```

Computer-Generated Stereoscopic Images

Program 1, Page 60

```
10 '        *****************************************************
20 '        *  PROGRAM TO PRODUCE STEREOSCOPIC PAIRS OF IMAGES  *
30 '        *     (c) Scott Camazine and Westy Dain, 1983       *
40 '        *       adapted for the IBM-PC from Byte, 1979      *
50 '        *****************************************************
60 '
70 ' The program is based on 2 equations which convert any set of three-
71 '   dimensional points in space (with coordinates x,y and z) to two
72 '   sets of points projected on a plane, one for each eye to view
80 '   separately. In other words the 3-D image as seen by the right
81 '   eye is projected onto a plane and next to it the 3-D image as seen
90 '   by the left eye is projected onto a plane. The images are then fused
91 '   to produce the original three-dimensional image.
100 '
110 ' For more details see "The XYZ phenomenon" BYTE, OCT. 1979
120 '   The equations are as follows:
125 '
```

(Stereoscopic/prog. 1/continued from p. 191)

```
130 '     X1 = [(X-E) * ZO/Z +E] * F
135 '     X2 = [(X+E) * ZO/Z -E] * F
140 '     Y1 = Y2 = [ Y * ZO/Z ] * F
150 '
160 '  Where: E is the distance from the center of your face to each eye
161 '         (thus 2E is the interocular distance, about 2.5 inches)
170 '        ZO is the distance from your eyes to the plane upon which we
171 '              project the images (6 inches is a good viewing distance)
180 '        Z  is the distance to the object (30 inches is good)
190 '        X1,Y1 and X2,Y2 are the points for the left and right image,
195 '              respectively, that we generate from the equations and plot
200 '        F is a scaling factor to enlarge the image to a good size for
201 '              viewing
210 '
220 '   For this simple example I have used the coordinates of a cube
222 '        5 x 5 x 5 units in size, I put it nearly straignt ahead
230 '        by putting the left-hand side of the cube at X=1. I put the
231 '        cube a distance of 30 units away thus Z is either 30 (for
240 '        the front face) or 35 (for the back face). The coordinates
250 '        of the cube are given in the data statments at the end of the
260 '        listing.
290 '
336 SCREEN 1:KEY OFF: CLS
360   ZO = 6: F = 60: E = 1.25  'EQUATION PARAMETERS
361   CXL = 10                  'VARIABLES TO POSITION THE IMAGES
362   CXR = 250                 '   ON THE SCREEN
363   CY  = 10
365 '************** DRAW THE LEFT-HAND FIGURE *****************************
370 FOR I = 1 TO 8       'set up an array with the points to be plotted
380    READ X,Y,Z
390    X1(I)=((X - E ) * ZO/Z + E ) * F
400    Y1(I)=(Y * ZO/Z) * F
420 NEXT I
421 '
430 FOR I = 1 TO 7       'connect the points with lines
440    LINE (X1(I)+CXL,Y1(I)+CY)-(X1(I+1)+CXL,Y1(I+1)+CY)
450 NEXT I
460 LINE (X1(8)+CXL,Y1(8)+CY)-(X1(1)+CXL,Y1(1)+CY)
462 '
463 '************* DRAW THE RIGHT-HAND FIGURE ***************************
470 RESTORE
480 FOR I = 1 TO 8
490    READ X,Y,Z
500    X1(I)=((X+E) * ZO/Z - E) * F
510    Y1(I)=(Y * ZO/Z) * F
530 NEXT I
531 '
540 FOR I = 1 TO 7
550    LINE (X1(I)+CXR,Y1(I)+CY)-(X1(I+1)+CXR,Y1(I+1)+CY)
560 NEXT I
570 LINE (X1(8)+CXR,Y1(8)+CY)-(X1(1)+CXR,Y1(1)+CY)
573 '
576 '****************** COORDINATES OF THE CUBE IN 3-D ******************
580 DATA 1,5,30
590 DATA 1,10,30
600 DATA 6,10,30
610 DATA 6,5,30
620 DATA 1,10,35
630 DATA 1,5,35
640 DATA 6,10,35
650 DATA 6,5,35
655 END
```

Stereoscopic Images: Program 2, Page 60

```
10 '       ************************************************************
20 '       *      STEREOSCOPIC PAIRS OF AN ARCHIMEDES HELIX           *
30 '       *       (C) Scott Camazine and Westy Dain, 1983            *
40 '       ************************************************************
50 '
60 KEY OFF : SCREEN 1: CLS
70 '
80 ' ********** VARIABLES ****************************************
90        E  = 1.25     'THE INTEROCULAR DISTANCE
100      ZO  = 6        'THE DISTANCE TO THE PICTURE
110       F  = 20       'SCALING FACTOR
120       A  = 6        'CONTROLS THE `TIGHTNESS` OF THE SPIRAL
130       K  = 12
135      CXL = 60       'POSITIONING IMAGES ON THE SCREEN
136      CXR = 250
137       CY = 85
140 ' **************************************************************
150 FOR R = .001 TO 150  STEP .2
160     X = R * COS (R/A)                'COORDINATES OF THE HELIX
170     Y = R * SIN (R/A)
180     Z = K * R/A + 90
190     X1 = ((X-E) * ZO/Z + E) * F   'COORDINATES OF THE STEREO PAIRS
195     X2 = ((X+E) * ZO/Z - E) * F
200     Y1 = (Y * ZO/Z) * F
210     PSET(X1+CXL,Y1+CY)            'PLOTTING THE LEFT IMAGE
220     PSET(X2+CXR,Y1+CY)            'PLOTTING THE RIGHT IMAGE
230 NEXT R
240 END
```

Stereoscopic Images: Program 3, Page 60

```
10 ' ************  GENERATION OF 3-D LISSAJOUS FIGURE STEREO PAIRS **********
15 '
20 '            (C) Scott Camazine and Westy Dain
25 '            adapted from BYTE, October, 1979
27 '
40 '  VARYING THE PARAMETERS A,B,C,Q,R,S,G GENERATES OTHER LISSAJOUS FIGURES
50 '
60 ' The following sets of parameters yield good figures:
62 '
63 '    A        B        C        Q        R        S        G
64 ' --------------------------------------------------------------
65 '    4        2        8        8        3        5        0
66 '    4        2        8        2        3        5        0
67 '    4        2        8        2        3        7        0
68 '    4        2        8        2        3        0        1
70 '
110 KEY OFF : CLS: SCREEN 2
120 '
130 ' ***************** VARIABLES ******************************************
140 '
150 A=4: B=2.3: C=8: Q=4: R=2: S=0: T=3: G=1    ' LISSAJOUS EQUATION PARAMETERS
160 '
170 ' TRANSFORMATION EQUATION AND PLOTTING PARAMETERS
180 '
190    E = 1.25  'distance from the nose to the eye (inches)
200    F = 100   'scaling factor for the size of the figure
210   ZO = 6     'distance at which the stereo pairs are to be viewed (inches)
220    D = 30    'distance from eye to location of Lissajous figure in space
230 CXL = 75     'variable to position the image on the screen
233 CXR = 600
234  CY = 100
240 ' **************** GENERATE THE PAIRS OF FIGURES *************************
250 '
260 FOR W = 1 TO 8  STEP .01 'Smaller steps give a smoother picture
270     X = A*SIN(Q*W*T)     'general equation for lissajous figures in space
280     Y = B*SIN(R*W*T)
290     Z = C*SIN(S*W*T) + G*W*10
300     X1=((X-E)*ZO/(Z+D)+E)*F   ' equations which transform a point in
310     X2=((X+E)*ZO/(Z+D)-E)*F   ' space to points on the viewing plane
320     Y1=(Y*ZO/(Z+30))*F
330     PSET(X1+CXL,Y1+CY)
340     PSET(X2+CXR,Y1+CY)
350 NEXT W
360 END
```

Stereoscopic Images: Program 4, Page 60

```
10 ' ************************************************************************
12 ' *                                                                      *
14 ' *          GENERATES RANDOM DOT THREE-DIMENSIONAL STEREOSCOPIC PAIRS   *
16 ' *                                                                      *
17 ' *                        PROGRAM BY SCOTT CAMAZINE                     *
18 ' *                                                                      *
19 ' *     Adapted From Bela Julesz (Scientic American, February 1965       *
20 ' *                                                                      *
22 ' ************************************************************************
24 '
26 '
28 '
65 KEY OFF
70 CLS
75 RANDOMIZE VAL(RIGHT$(TIME$,2))
77 SCREEN 1
80 '
81 ' ************* PARAMETERS ***********************************************
82 OX = 40  'offset in the horizontal (x) direction to position image on screen
83 OY = 20  'offset in the vertical (y) direction to position image on screen
84 IP = 10  'distance between right and left images
85 S = 6    'shift of the central squares (change sign to make squares recede)
88 '
95 ' ****************** FILL TWO LARGE SQUARES WITH THE SAME RANDOM DOT PATTERN
110 FOR R = 1 TO 100
120     FOR C = 1 TO 100
125         Y = RND
```

(continued on p. 194)

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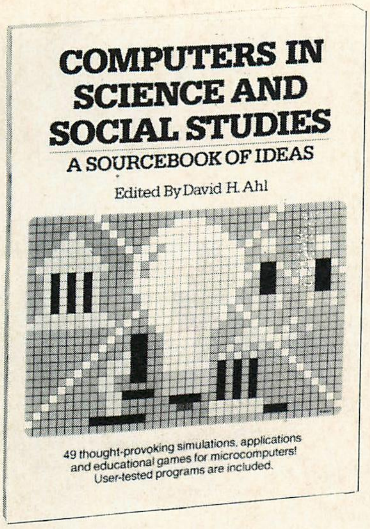

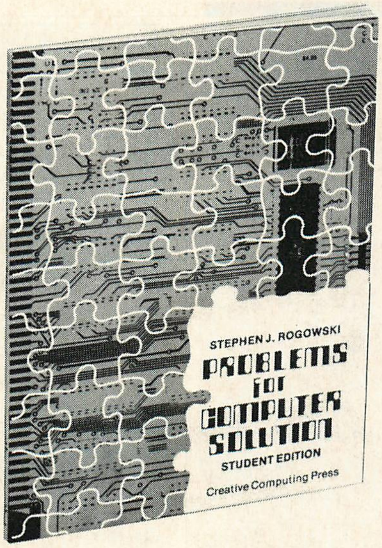

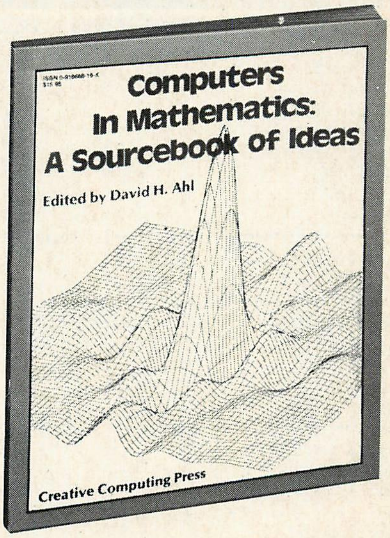

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(Stereoscopic, prog. 4, continued from p. 192)

```
130         IF Y < .5 THEN GOSUB 170
150     NEXT C
160 NEXT R
165 GOTO 310
170 PSET(R+OX,C+OY)
180 PSET(R+OX+100+IP, C+OY)
190 RETURN
195 '
301 '
302 '**************** CLEARS THE SMALL SQUARE ****************************
310 FOR R = 1 TO 50
320   FOR C = 1 TO 50
325     PRESET(R+OX+25+S,C+OY+25)
330     PRESET(R+OX+100+IP+25-S,C+OY+25)
350     NEXT C
360 NEXT R
365 '
366 '
505 '*********** FILL THE SQUARES WITH IDENTICAL RANDOM DOT PATTERN *********
510 FOR R = 1 TO 50
520     FOR C = 1 TO 50
525         Y = RND
530         IF Y < .5 THEN GOSUB 570
550     NEXT C
560 NEXT R
565 END
570 PSET(R+OX+25+S,C+OY+25)
580 PSET(R+OX+100+IP+25-S,C+OY+25)
590 RETURN
```

A Diversionary Benchmark

Program 1, Page 169

```
($N+)(TURN ON NATIVE CODE GENERATION)
(R-)(TURN OFF RANGE CHECKING)
USES TURTLEGRAPHICS;

CONST
  P=160;
  Q=100;
  XP=144;
  YP=56;
  ZP=64;

VAR
  XI, YI, ZF, XF, ZT, XT, XR, YY, XPZP : REAL;
  XP2, ZI, XL, XI : INTEGER;
  FOREVER : BOOLEAN;
  A : INTEGER;

  BEGIN (** MAIN PROGRAM **)
    XR := 1.5*3.1415927;
    XF := XR/XP;
    XPZP := XP/ZP;
    XP2 := XP*XP;

    ZF := XR/ZP;
    FOREVER := FALSE;

    FOR ZI := -Q TO Q+1 DO
      BEGIN
        IF (ZI > -ZP) AND (ZI < ZP) THEN
          BEGIN
            ZT := ZI * XPZP;
            XL := TRUNC (0.5 + SQRT (XP2 - ZT*ZT));
            FOR XI := -XL TO XL DO
              BEGIN
                XT := SQRT (XI*XI + ZT*ZT) * XF;
                YY := (SIN (XT) + 0.4 * SIN (3 * XT)) * YP;
                XI := XI + ZI + P;
                YI := YY - ZI + Q;
                SETPIXEL (0, XI, YI, 2);
              END;
          END; (IF)
      END; (NEXT ZI)

      REPEAT
        A := A+1
      UNTIL FOREVER;

  END. (** MAIN PROGRAM **)
```

Benchmark, Prog 2, Page 160

```
100 ' Hat
110 CLS: SCREEN 1
120 P=160: Q=100
130 XP=144: XR=1.5*3.1415927#
140 YP=56: YR=1: ZP=64
150 XF=XR/XP: YF=YP/YR: ZF=XR/ZP
160 FOR ZI = -Q TO Q-1
170   IF ZI < -ZP OR ZI > ZP GOTO 250
180   ZT=ZI*XP/ZP: ZZ=ZI
190   XL=INT(.5+SQR(XP*XP-ZT*ZT))
200   FOR XI = -XL TO XL
210     XT=SQR(XI*XI + ZT*ZT)*XF: XX = XI
220     YY=(SIN(XT)+.4*SIN(3*XT))*YF
230     GOSUB 270
240   NEXT XI
250 NEXT ZI
260 STOP
270 X1=XX+ZZ+P
280 Y1=YY-ZZ+Q
290 Y1=200-Y1
300 PSET(X1,Y1),2
310 IF Y1=200 GOTO 330
320 LINE (X1,Y1+1)-(X1,200),0
330 RETURN
```

Controlled Plotting

Program 1, Page 103

```
10 SCREEN 2:CLS:KEY OFF
20 DIM DTA(300):YMAX=0 :YMIN=0
30 LOCATE 12,20 : PRINT "PLEASE BE PATIENT DURING CALCULATIONS "
40 XMIN=0 : XMAX=6.28                      'One period to be plotted
50 FOR I=0 TO 299
60 DTA(I)=SIN(THETA)                       'Fill data array
70 THETA =THETA+(XMAX/300)
80 IF DTA(I)<YMIN THEN YMIN=DTA(I)
90 IF DTA(I)>YMAX THEN YMAX=DTA(I)
100 NEXT
110 CLS
120 ' PICK THE FIRST WINDOW
130 W11=.3 : W12=.7                        'Central 40% of horiz. display area
140 W21=.3 : W22=.7                        'Central 40% of vert. display area
150 ' MAKE IT LOOK NICE
160 LOCATE 25,35 : PRINT "FIGURE 1."
170 LINE (192,100)-(448,100)               'Horizontal line
180 LINE (192,60)-(192,140)                'Vertical line
190 LOCATE 7,33 : PRINT "SINE CURVE PLOT"
200 ' START TO DO THE WORK
210 GOSUB 440                              'Calculate parameters
220 GOSUB 320                              'Plot in desired screen window
230 W11=0 :W12=.2:W21= .8  :W22= 1         'Upper left
240 GOSUB 440:GOSUB 320
250 W21=0  : W22=.2                        'Lower left
260 GOSUB 440:GOSUB 320
270 W11=.8:W12=1                           'Lower right
280 GOSUB 440:GOSUB 320
290 W21=.8 : W22=1!                        'Upper right
300 GOSUB 440:GOSUB 320
310 A$=INKEY$:IF A$="" GOTO 310 ELSE END
320 '   PLOTTING SUBROUTINE
330 THETA=0
340 FOR I=0 TO 299
350 X.DATA.POINT=THETA
360 Y.DATA.POINT=DTA(I)
370 REM   ***  CALCULATE SCREEN POSITIONS  ***
380 XPLOT=INT(T11+T12*X.DATA.POINT)     'Horizontal position
390 YPLOT=INT(T21+T22*Y.DATA.POINT)     'Vertical position
400 PSET ( XPLOT, YPLOT )
410 THETA = THETA + XMAX/300
420 NEXT I
430 RETURN
440 ' SUBROUTINE FOR PARAMETER CALCULATION
450 T12=640*(W12-W11)/(XMAX-XMIN)
460 T11=0 +W11*640-T12*XMIN
470 T22=(0-200)*(W22-W21)/(YMAX-YMIN)
480 T21=200 + W21*(0-200)-T22*YMIN
490 RETURN
```

(continued on page 196)

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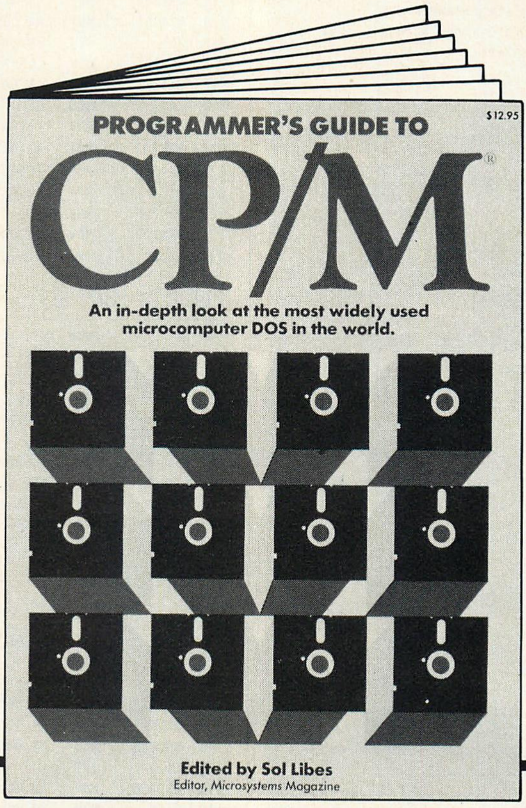

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(continued from page 194)

Program 2, Page 169

```
10 SCREEN 2:CLS:KEY OFF
20 DIM DTA(300):YMAX=0 :YMIN=0
30 LOCATE 12,19 : PRINT "PLEASE BE PATIENT DURING CALCULATIONS "
40 XMIN=0 : XMAX=6.28*5                 'Five periods to be plotted
50 FOR I=0 TO 100
60 DTA(I)=SIN(THETA)                    'Fill data array
70 THETA =THETA+(XMAX/100)
80 IF DTA(I)<YMIN THEN YMIN=DTA(I)
90 IF DTA(I)>YMAX THEN YMAX=DTA(I)
100 NEXT
110 CLS
120 W11=.3 : W12=.7                     'Central 40% of horiz. display area
130 W21=.3 : W22=.7                     'Central 40% of vert. display area
135 LOCATE 25,35: PRINT"FIGURE 2."
140 LINE (192,100)-(448,100)            'Horizontal line
150 LINE (192,60)-(192,140)             'Vertical line
160 LOCATE 7,33 : PRINT "SINE CURVE PLOT"
170 GOSUB 440                           'Calculate parameters
180 GOSUB 290                           'Plot in desired screen window
190 W11=0 :W12=.2:W21= .8  :W22= 1      'Upper left
200 GOSUB 440:GOSUB 290
210 W21=0  : W22=.2                     'Lower left
220 GOSUB 440:GOSUB 290
230 W11=.8:W12=1                        'Lower right
240 GOSUB 440:GOSUB 290
250 W21=.8 : W22=1!                     'Upper right
260 GOSUB 440:GOSUB 290
280 A$=INKEY$:IF A$="" GOTO 280 ELSE END
290 '   PLOTTING SUBROUTINE
300 THETA=0
310 FOR I=0 TO 100
320 X.DATA.POINT=THETA
330 Y.DATA.POINT=DTA(I)
340 REM   ***  CALCULATE SCREEN POSITIONS  ***
350 XPLOT= T11+T12*X.DATA.POINT         'Horizontal position
360 YPLOT= T21+T22*Y.DATA.POINT         'Vertical position
370 PSET ( XPLOT, YPLOT )
380 IF THETA=0 THEN X1=XPLOT : Y1=YPLOT
390 LINE (X1,Y1)-(XPLOT,YPLOT)
400 SWAP X1,XPLOT : SWAP Y1,YPLOT
410 THETA = THETA + XMAX/100
420 NEXT I
430 RETURN
440 ' SUBROUTINE FOR PARAMETER CALCULATION
450 T12=640*(W12-W11)/(XMAX-XMIN)
460 T11=0 +W11*640-T12*XMIN
470 T22=(0-200)*(W22-W21)/(YMAX-YMIN)
480 T21=200 + W21*(0-200)-T22*YMIN
490 RETURN
```

Display Character Set Customization

Figure 1, Page 123

```
100  E9FD00       JMP   200            ; skip to the main program

; 103-1E2 is a translation table and thus has no assembly
; language meaning.
; If using an assembler, these lines must be DB statements.

103            20 21 22 23 24 25 26 27 28 29 2A 2B 2C
110  2D 2E 2F 30 31 32 33 34 35 36 37 38 39 3A 3B 3C
120  3D 3E 3F 40 41 42 43 44 45 46 47 48 49 4A 4B 4C
130  4D 4E 4F 50 51 52 53 54 55 56 57 58 59 5A 5B 5C
140  5D 5E 5F 60 61 62 63 64 65 66 67 68 69 6A 6B 6C
150  6D 6E 6F 70 71 72 73 74 75 76 77 78 79 7A 7B 7C
160  7D 7E 7F 80 81 82 83 84 85 86 87 88 89 8A 8B 8C
170  8D 8E 8F 90 91 92 93 94 95 96 97 98 99 9A 9B 9C
180  9D 9E 9F A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC
190  AD AE AF B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC
1A0  BD BE BF C0 C1 C2 C3 C4 C5 C6 C7 C8 C9 CA CB CC
1B0  CD CE CF D0 D1 D2 D3 D4 D5 D6 D7 D8 D9 DA DB DC
1C0  DD DE DF E0 E1 E2 E3 E4 E5 E6 E7 E8 E9 EA EB EC
1D0  ED EE EF F0 F1 F2 F3 F4 F5 F6 F7 F8 F9 FA FB FC
1E0  FD FE FF


1E3  3C20         CMP  AL,20           ; is char under 20?
1E5  720A         JB   01F1            ; jump to 1F1 if it is
1E7  2C20         SUB  AL,20           ; adjust the code value
1E9  FFF3         PUSH BX              ;
1EB  BB0301       MOV  BX,0103         ;  put the offset of the table in BX and
1EE  2E           SEG  CS              ;  translate, using the table in BX, and
1EF  D7           XLAT                 ;  leaving the new values in AL
1F0  5B           POP  BX              ;
1F1  EA00000000 JMP  0000,0000         ; see 21C below

; 1F6-1FF are all 00; offset 200 begins the transient portion of the program
; (this is necessary)

200  1E           PUSH  DS             ;
201  2BC0         SUB   AX,AX          ;  prepare the stack for INT 27
203  50           PUSH  AX             ;
204  8ED8         MOV   DS,AX          ;
206  39064001     CMP   [0140],AX      ;  skip to 218 if abs. 140-143 has data
20A  750C         JNZ   0218           ;
20C  A14000       MOV   AX,[0040]      ;
20F  A34001       MOV   [0140],AX      ;  move the address currently at abs.
212  A14200       MOV   AX,[0042]      ;  0040-0043 to abs. 0140-0143
215  A34201       MOV   [0142],AX      ;
218  A14001       MOV   AX,[0140]      ;
21B  26           SEG   ES             ;
21C  A3F201       MOV   [01F2],AX      ;  move the address at abs. 0140-0143 into
21F  A14201       MOV   AX,[0142]      ;  lines 1F2-1F5 of this program
222  26           SEG   ES             ;
223  A3F401       MOV   [01F4],AX      ;
226  B8E301       MOV   AX,01E3        ;
223  A34000       MOV   [0040],AX      ;  make INT 10 point to this program
22C  8CC8         MOV   AX,CS          ;  in this segment
22E  A34200       MOV   [0042],AX      ;
231  BA0002       MOV   DX,0200        ; mark the end of the resident portion
234  CD27         INT   27             ; return to DOS
```

Figure 2, Page 123

```
100 1E          PUSH DS            ;
101 2BC0        SUB  AX,AX         ;  prepare the stack for INT 20
103 50          PUSH AX            ;
104 8ED8        MOV  DS,AX         ;
106 39064001    CMP  [0140],AX     ;  do nothing if abs. [0140] is empty
10A 740C        JZ   0118          ;
10C A14001      MOV  AX,[0140]     ;
10F A34000      MOV  [0040],AX     ;  move the contents of abs. 0140-0143
112 A14201      MOV  AX,[0142]     ;  to abs. 0040-0043
115 A34200      MOV  [0042],AX     ;
118 CD20        INT  20            ; return to DOS
```

Figure 3, Page 124

```
100  1E          PUSH  DS           ;
101  2BC0        SUB   AX,AX        ;  prepare the stack for INT 20
103  50          PUSH  AX           ;
104  89C1        MOV   CX,AX        ;
106  BA7924      MOV   DX,2479      ;  with CX=0000, DX=2479, BH=07
109  B707        MOV   BH,07        ;  and AX=0600, INT 10
10B  B80006      MOV   AX,0600      ;  will clear screen
10E  CD10        INT   10           ;
110  BA0000      MOV   DX,0000      ;  with AH=02 and BH=00, INT 10
113  B700        MOV   BH,00        ;  will move the cursor to the location
115  B402        MOV   AH,02        ;  given in DX (top right corner)
117  CD10        INT   10           ;
119  BA3601      MOV   DX,0136      ;  with AH=09, INT 21 will print
11C  B409        MOV   AH,09        ;  string ending with $ found at
11E  CD21        INT   21           ;  the offset given in DX
120  BA0B03      MOV   DX,030B      ;
123  B402        MOV   AH,02        ;  with AH=02, INT 10 locates cursor for $
125  CD10        INT   10           ;
127  B224        MOV   DL,24        ;
129  B402        MOV   AH,02        ;  with AH=02, INT 21 will print
12B  CD21        INT   21           ;  the character in DL ($)
12D  BA0016      MOV   DX,1600      ;
130  B402        MOV   AH,02        ; INT 10 will now move the cursor to 16,00
132  CD10        INT   10           ;
134  CD20        INT   20           ; return to DOS

; Beginning at offset 136 is the actual display; since assembly
; language is meaningless here, only object code (in hexadecimal)
; will be given

136                    43 55-52 52 45 4E 54 20 43 48
140  41 52 41 43 54 45 52 20-53 45 54 3A 0D 0A 0A 0A
150  20 20 21 20 20 40 20 20-23 20 20 00 20 20 25 20
160  20 5E 20 20 26 20 20 2A-20 20 28 20 20 29 20 20
```

(continued on page 199)

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PROGRAM LISTINGS

(Display, fig. 3, continued from p. 196)

```
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180  45 20 20 52 20 20 54 20-20 59 20 20 55 20 20 49
190  20 20 4F 20 20 50 20 20-7B 20 20 7D 20 20 0D 0A
1A0  0A 20 20 20 20 41 20 20-53 20 20 44 20 20 46 20
1B0  20 47 20 20 48 20 20 4A-20 20 4B 20 20 4C 20 20
1C0  3A 20 20 22 20 7E 0D 0A-0A 20 20 7C 20 20 5A 20
1D0  20 58 20 20 43 20 20 56-20 20 42 20 20 4E 20 20
1E0  40 20 20 3C 20 20 3E 20-20 3F 0D 0A 0A 0A 0A 20
1F0  20 31 20 20 32 20 20 33-20 20 34 20 20 35 20 20
200  36 20 20 37 20 20 38 20-20 39 20 20 30 20 20 2D
210  20 20 3D 20 20 0D 0A 0A-20 20 20 71 20 20 77 20
220  20 65 20 20 72 20 20 74-20 20 79 20 20 75 20 20
230  69 20 20 6F 20 20 70 20-20 5B 20 20 5D 0D 0A 0A
240  20 20 20 20 61 20 20 73-20 20 64 20 20 66 20 20
250  67 20 20 68 20 20 6A 20-20 6B 20 20 6C 20 20 3B
```

Figure 4, Page 126

```
Note: the first 20 hx characters (00-1F) cannot be altered.

dec hx         dec hx       dec hx       dec hx        dec hx        dec hx

 32 20 blank   48 30 0      64 40 @      80 50 P        96 60 `      112 70 p
 33 21 !       49 31 1      65 41 A      81 51 Q        97 61 a      113 71 q
 34 22 "       50 32 2      66 42 B      82 52 R        98 62 b      114 72 r
 35 23 #       51 33 3      67 43 C      83 53 S        99 63 c      115 73 s
 36 24 $       52 34 4      68 44 D      84 54 T       100 64 d      116 74 t
 37 25 %       53 35 5      69 45 E      85 55 U       101 65 e      117 75 u
 38 26 &       54 36 6      70 46 F      86 56 V       102 66 f      118 76 v
 39 27 '       55 37 7      71 47 G      87 57 W       103 67 g      119 77 w
 40 28 (       56 38 8      72 48 H      88 58 X       104 68 h      120 78 x
 41 29 )       57 39 9      73 49 I      89 59 Y       105 69 i      121 79 y
 42 2A *       58 3A :      74 4A J      90 5A Z       106 6A j      122 7A z
 43 2B +       59 3B ;      75 48 K      91 5B [       107 6B k      123 7B {
 44 2C ,       60 3C <      76 4C L      92 5C \       108 6C l      124 7C |
 45 2D -       61 3D =      77 4D M      93 5D ]       109 6D m      125 7D }
 46 2E .       62 3E >      78 4E N      94 5E ^       110 6E n      126 7E ~
 47 2F /       63 3F ?      79 4F O      95 5F _       111 6F o      127 7F

Note: from 7F hex on, the characters are not available
      on an ASCII printwheel.

 dec hx   dec hx   dec hx   dec hx   dec hx   dec hx   dec hx   dec hx

 128 80   144 90   160 A0   176 B0   192 C0   208 D0   224 E0   240 F0
 129 81   145 91   161 A1   177 B1   193 C1   209 D1   225 E1   241 F1
 130 82   146 92   162 A2   178 B2   194 C2   210 D2   226 E2   242 F2
 131 83   147 93   163 A3   179 B3   195 C3   211 D3   227 E3   243 F3
 132 84   148 94   164 A4   180 B4   196 C4   212 D4   228 E4   244 F4
 133 85   149 95   165 A5   181 B5   197 C5   213 D5   229 E5   245 F5
 134 86   150 96   166 A6   182 B6   198 C6   214 D6   230 E6   246 F6
 135 87   151 97   167 A7   183 B7   199 C7   215 D7   231 E7   247 F7
 136 88   152 98   168 A8   184 B8   200 C8   216 D8   232 E8   248 F8
 137 89   153 99   169 A9   185 B9   201 C9   217 D9   233 E9   249 F9
 138 8A   154 9A   170 AA   186 BA   201 CA   218 DA   234 EA   250 FA
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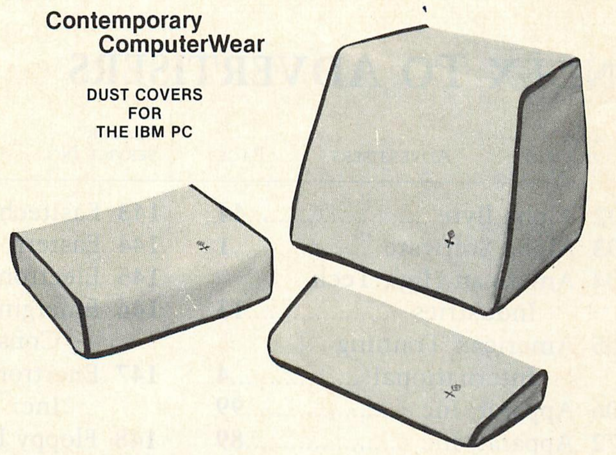

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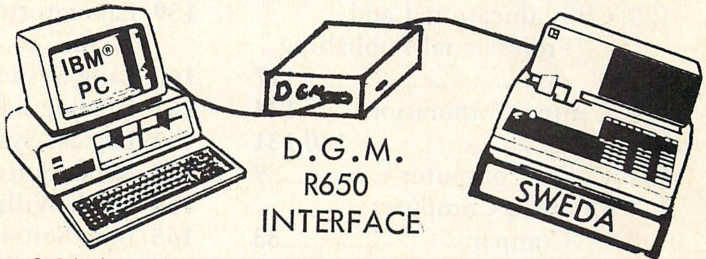

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